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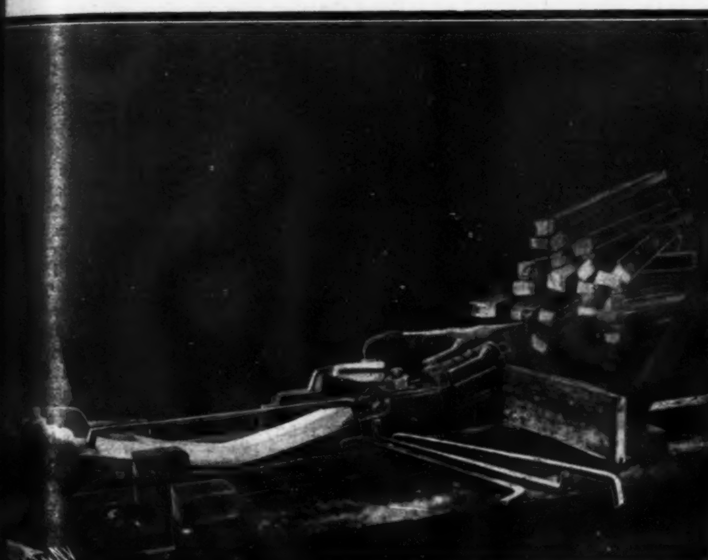
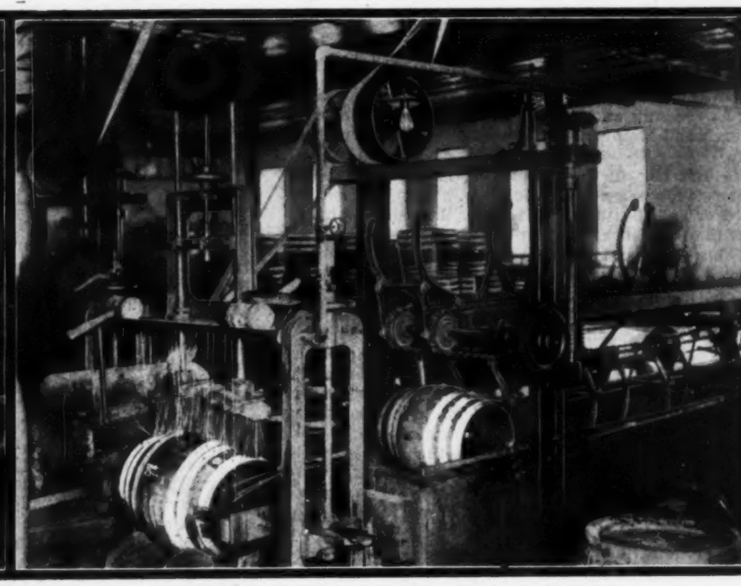
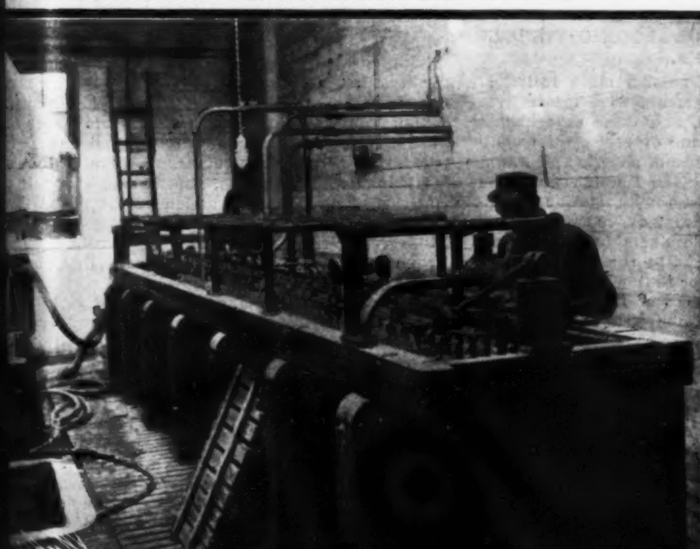


THE STAVE BUCKER, SHOWING WOOD HELD BY "SPAN DOG."

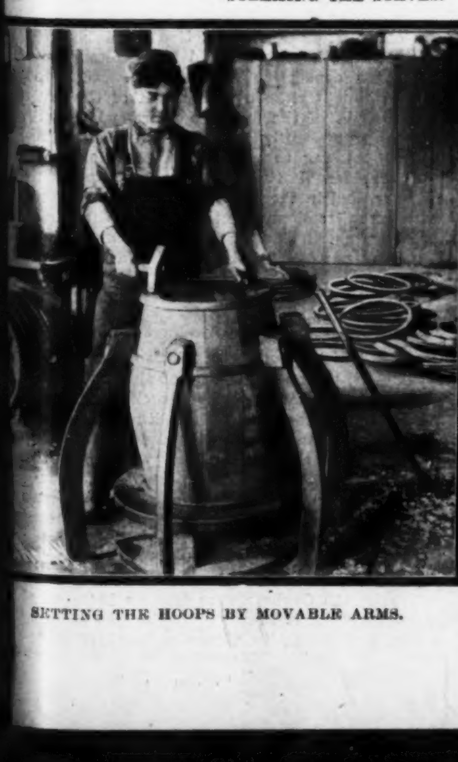


SCRUBBING THE KEGS BY MECHANICAL BRUSHES.

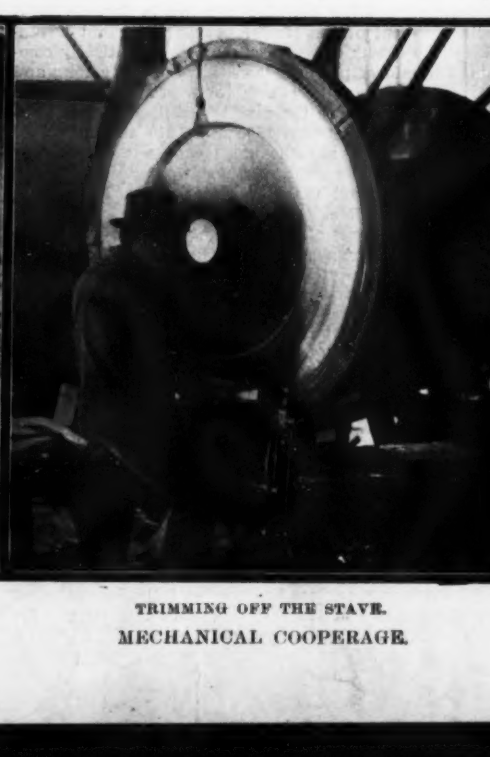


STEAMING THE STAVES.

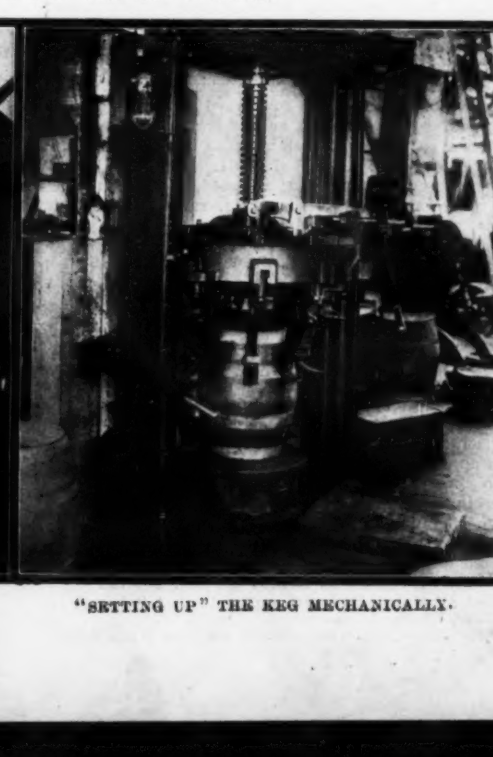
IN THE "CROZING" MACHINE.



SETTING THE HOOPS BY MOVABLE ARMS.



TRIMMING OFF THE STAVE.



"SETTING UP" THE KEG MECHANICALLY.

MECHANICAL COOPERAGE.

MECHANICAL COOPERAGE.*

By DAY ALLEN WILLEY.

THE invention of the various mechanical devices which have so revolutionized the cooperage industry has been due largely to the demand for casks and barrels of special strength in order to hold the quantity and kinds of liquids for which they are intended. The modern liquor cask, for example, would represent a large amount of labor if it were fashioned by the cooper using merely hand tools, and it would probably be impossible to make one which would withstand the pressure to which the machine-made cask is subjected, as well as the rough handling it receives in transportation. In the modern processes employed, however, surprisingly little hand labor is required, power appliances doing practically all of the work except setting in the heads, which is generally done by the cooper. The materials which enter into the manufacture of the ordinary keg or cask render necessary the employment of powerful machinery, especially in fitting and shaping, as the wood preferred is oak, owing to its toughness and durability, while the hoops are of much heavier metal than those used in dry cooperage. Consequently the average bucker, planer, and hollower, as well as trussing and crozing apparatus, weigh over a ton each and require from 4 to 6 horse-power for operation.

The first step in the keg-making is the preparation of the staves to compose the body. These are either sawed or split by the machinery in the usual manner. Then they are bucked—narrowed to the proper width. The "bucker" consists of a steel carriage into which the stave is clamped by means of a foot lever. The carriage is forced by a ram into such a position that the stave passes between two cutters or knives, which shave it to the requisite proportions, the width in the center being somewhat more than at the ends in order to give the keg the proper "belly" or bulge. The inside of the stave is hollowed out also by a power tool, under which it is carried mechanically—set in the hollower bed, as it is termed. The cutting tool is sometimes set in a rotary wheel against which the inner surface of the stave is pressed. The next step before the bending is to "joint" it—trim off the material to the requisite length. This is done with a circular saw as in the case of ordinary woodworking.

The manufacture of kegs differs from that of barrels, especially in the treatment of the wood to make it pliable or more easy to bend. This process is the last in shaping the staves to give them the proper form, and before being placed in the bender, they are usually steamed for a period ranging from 30 minutes to an hour, depending largely on the variety and seasoning of the wood. The steam vats are equipped with endless sprocket chains to which are attached hooks for holding the staves. As fast as the steaming is finished, one operator can remove them from the slowly revolving conveyor. The bender may be an upright or horizontal machine, but in either case it contains an adjustable cradle or model into which the wood is set and firmly held at each end by means of screw heads or bolts. By the operation of a lever the cradle is contracted into a curve of the shape which the stave is to form. Before the stave is released, a bar of iron bent at each end is forced over it to hold it in position until it has cooled, when it will retain the curve made by the bender. This bar is called the "span-dog," and as a rule it is required to be nearly half the thickness of the wood it holds, such is the force which it is utilized to counteract.

With the bending, the preliminary work is ended in making the body of the keg, and the material is ready for setting up. Taking a sufficient number of staves, the cooper assembles them and holds them together loosely by slipping over one end two of the truss hoops. There are several ways of completing the form of the body. One is to adjust a rope around the end which is not hooped, then draw the rope taut by winding it on a drum, thus forcing the pieces into position; but a far better method is the use of what is termed the trusser. This consists of a heavy iron upright framework in which is set a pedestal or base of cast iron on which the keg stands. Above the keg is a metal disk to which are attached what are called hooks. These are adjustable, so they can be clamped against the hoops to be set, pressing downward and inward. The disk moves up and down on the track formed by the framework, its power being applied by means of a screw operated by a belted shaft. When the keg is to be trussed, the hoops are adjusted, and a turn of the lever forces the disk upon them, ramming the hoop home, and at the same time binding the staves firmly together. In another form of truss the keg is placed on an iron platform inclosed by movable arms which can be clamped against the sides and above the hoops. They are attached to a disk or cylinder below the platform and pull the hoops into place instead of forcing them down from above. The hoops are galvanized by electricity.

The package is now ready to be fitted for the head, or "crozed." This is also performed entirely by mechanical power, but in the crozing machine it is placed horizontally instead of vertically. In its operation this apparatus is somewhat similar to a turning lathe. Two rings of heavy steel called the "chuck rings" engage the ends of the keg, which revolves within them. Connected with each chuck ring is a circular cutter head which can be moved inside of the keg and the knives adjusted so as to cut the groove into which the heads fit. This is termed crozing, but the cutter can also be moved at such an angle that it bevels the edges of the staves or "chamfers" them so that the head can be readily forced into place. The final operation is to finish the outside. This is performed by a form of plane which can be adjusted to the curved surface, the keg being mounted on a carriage which conveys it back and forth under the cutting tool. After this it is usually cleaned by passing it through a tank of hot water, then turning it on rollers set beneath a pair of stiff brushes which scrub the staves, while another pair set opposite to each other in the ends of the machine scrub the heads. Meanwhile the surface is rinsed with jets of water thrown against it.

The manufacture of the heads is, of course, entirely distinct from the fashioning of the body of the keg. They are rarely formed of one piece of wood, but generally of three and sometimes four to give greater strength. These are first sawed to the requisite thickness, then the dowel holes are bored in their edges by power augurs. After the dowels, which are merely wooden pins, have been placed in the holes, the pieces are joined by means of them and clamped between two revolving disks which, as they turn, press the several pieces firmly together and set them in place. With this operation completed, the edges of the head are ready for trimming and beveling. These operations are performed by placing it on a saw table and moving it against cutter heads set at the proper angle.

A very essential operation where the kegs are intended to hold malt liquor, is "pitching." The inside is coated with this substance before the keg is used, and in the larger breweries it is generally pitched after being cleaned, preparatory to refilling. As the coating is applied after the keg is completed, an ingenious device is employed by which the pitch in liquid form is introduced through the bung hole. It is placed in a reservoir connected with steam pipes which heat it to the boiling point. In the reservoir is a miniature turbine which is revolved by steam power. The action of the turbine forces the pitch through a valve inserted in the bung hole, throwing it against the interior of the keg in a circular jet similar to that which issues from the ordinary lawn sprinkler. The valve is regulated entirely by the weight of the keg and is open only when the keg is placed upon the spring levers which control it. The "pitching" is done in less than a minute, and as the keg is lifted the steam is automatically shut off from the turbine by the closing of the valve which also cuts off the flow of pitch. Our photographs were made in the cooperage of the Pabst plant at Milwaukee.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SUPERHEATED STEAM FOR LOCOMOTIVES IN GERMANY.

SINCE the year 1898 the Prussian state railroads have been carrying on experiments with locomotives employing superheated steam, and these experiments have done much to elucidate and overcome the technical difficulties incident to the use of superheated steam by locomotives. While during the last ten years the utilization of superheated steam with stationary engines has become general in Germany, it has been employed only on a small scale during the past few years with locomotives. Owing to the great amount of power which a locomotive of limited size must produce, it is far less economical of steam than the stationary engine, whose bulk is subject to no limitation, and its steam is far more heavily charged with moisture, so that theoretically, at least, the advantages obtained by the use of superheated steam in locomotives should be greater than in stationary engines.

Superheated steam differs from ordinary steam in being a bad conductor of heat, so that it is not liquefied even when a considerable amount of its heat is given off in the cylinders, and the amount of heat lost by contact with the walls of the cylinder is much less than the amount lost by saturated steam, which is now used for the propulsion of locomotives. Superheated steam possesses the further advantage that it fills a greater space than the same amount of saturated steam at the same tension, the amount of superheated steam necessary to fill a cylinder varying in inverse ratio with the heat of the steam. These important advantages, the effects of which can be mathematically computed by aid of physical laws, have led to a long and persevering series of efforts to overcome the serious difficulty incident to the practical utilization of superheated steam. Between 1830 and 1840 attempts were made to utilize superheated steam with stationary engines, but the results obtained were unsatisfactory, owing to the fact that the materials used were not sufficiently durable.

The experiments of Hirn in the year 1850 were more successful, superheaters being constructed of cast iron, but the fact that the power of the superheated steam increased with its temperature had not been scientifically proved, and as the parts of the machine coming into contact with the steam were found to suffer when the temperature of 260 deg. C. was passed, no higher temperatures were attained. It was left for Engineer Schmidt, of Wilhelmshöhe, to demonstrate that the use of highly superheated steam, at 300 and 350 deg. C., materially reduces the amount of steam required, and that it can be used without injury to properly constructed machinery. At this time, something over ten years ago, materials sufficiently durable to withstand the action of superheated steam had been found, and a lubricating oil inflammable only at a very high temperature had been discovered.

The saving attained by the use of superheated steam with stationary engines has been so fully demonstrated by the practice of the last ten years that its use for this purpose has become general in Germany, and practically all new stationary machines are equipped with superheaters. One of the largest builders of steam machines in Germany claims a minimum saving of 15 per cent of the amount of coal consumed by the substitution of superheated for the ordinary saturated steam. In some instances it has been calculated that the saving is as high as 40 per cent. It has been demonstrated that a very material advantage is attained when the machinery and pipes are constructed and installed according to the most advanced principles.

While in the larger plants in the United States superheated steam has been introduced, it is far less extensively used than in Germany and other European countries.

Encouraged by success with stationary engines, Mr. Schmidt turned his attention to the technically more difficult task of utilizing superheated steam in locomotives. Steam is heated in the Schmidt superheater for locomotives by means of furnace gas introduced into an inclosed chamber (the superheater) by means of a large flue. The superheater, through which the hot air passes on its way to the smokestack, is circular in form and is located in the smoke box. In it are the pipes in which the steam is superheated, and they are so arranged that the steam coming from the boiler is made to pass three times through the superheater.

The first two engines equipped with superheaters, put into service in 1898 by the Prussian state railroads, are still running, and after various modifications had been made they gave, according to an official report, entire satisfaction, and are to-day considered two of the best twin engines for express and ordinary passenger service, in spite of the fact that they are in various respects not up to date in construction. The next order was for four twin locomotives in which the superheater was placed in the smoke box instead of in the boiler, and all of these engines have proved satisfactory, according to the report of Baurath Garbe, in respect to power, economy in the use of water and coal, and the ease with which they start. At present there are some fifty locomotives equipped with the Schmidt superheater in use or in course of construction for the Prussian state railroads, and all the different types of locomotives at present in use on this system are being tried with the Schmidt superheater. No official reports of the results obtained have been published more recently than 1902. In an article that appeared in Die Eisenbahn Technik der Gegenwart, a technical publication of high standing, published by C. W. Kriedel, of Wiesbaden, the results shown by the tests made public up to that time were summed up as follows:

"Superheated steam possesses properties that would, for technical and economic reasons, make its successful utilization on locomotives of material advantage.

"Locomotives using superheated steam under favorable conditions use 5 per cent less coal and 15 to 20 per cent less water than engines using saturated steam.

"Owing to its lightness, superheated steam is especially effective when the action of the piston is very rapid.

"A greater strain for a short time can be maintained by engines using superheated steam than by those using saturated steam."

Brückmann, one of the most indefatigable and exhaustive investigators, calculates that under normal conditions there is a saving of 20 per cent in an ordinary twin steam engine that employs superheated steam over one that does not, while the saving in coal is only one-half per cent when the work of a twin engine with superheater is compared with that of a compound engine without it. Owing to the difficulty of obtaining absolute accuracy, the results of the various tests of the efficiency of locomotives using superheated steam as compared with other engines have varied considerably, and there exists more or less difference of opinion as to the limit of economy in fuel and water that has been and is likely to be attained by the use of superheated steam.

It is the intention of Geheimrath Garbe, a constructing engineer of the Prussian state railroads who was responsible for the introduction of the superheater on that system, having devoted himself to rendering Mr. Schmidt's conception a practical success, to publish a report on it showing the result of the practice and experiments of the last two years, which will, he believes, triumphantly prove the great advantage of its use, but owing to various complications it is likely that considerable time will elapse before such a report appears, and in the meantime the reports made by the various railroad superintendents to the general management are not accessible. Personal investigation has, however, elicited the fact that a number of official reports of a favorable character on the work done by engines supplied with superheaters have been received. One of the most satisfactory of these reports relates to the work of two twin engines with superheater as compared with the work of two compound engines without it, the engines being of similar size and working for a year on the same track on alternate days, doing similar service. On one line the saving in coal of the twin engine over the compound engine was [illegible] per cent; on the second line, which ran through a somewhat hilly district, the saving in coal was 10 per cent. Furthermore, a second engine, which was needed to assist the compound engine over some steep grades, was not necessary with the twin engine, owing to the greater power obtained by the use of superheated steam.

Geheimrath Garbe claims that an increase of power of 30 per cent is attained by the use of superheated steam, but owing to somewhat contradictory results

obtained by different tests it is believed that absolutely accurate data as to the extent of the increase of power do not exist. The testimony of the Prussian railroad authorities tends, however, to show that it is very considerable. The saving of coal has been 20 per cent where the work of twin engines of the same type has been compared, but the highest economy in coal consumption obtained by the Schmidt superheater on a twin engine, when its work is compared with that of a compound engine, is 10 per cent. As the compound engine with four cylinders is of more complicated and expensive construction than the twin engine, the results given are very favorable.

Geheimrath Garbe maintains that in considering the question of expense the twin engine with superheater should be compared with the compound locomotive. He maintains that the use of the compound engine has been rendered desirable only by the defects of ordinary steam, that with highly superheated steam the simpler and less expensive twin engine, working with steam at much lower pressure, is capable of taking its place for all purposes, and that it will be possible by the use of superheated steam to reduce the types of engines used in Germany to five or six. He asserts that while the compound engine is more economical, is capable of attaining greater speed, and is more powerful at high speed than the twin engine when ordinary steam is used by both engines, the advantages of the compound engine disappear when it is compared with a properly-constructed twin engine using superheated steam at from 300 to 325 deg. C. He bases his judgment on experience obtained on the Prussian railroad and on the inherent superiority of highly superheated steam.

Scientific investigation has established the fact that the volume of steam superheated to 300 deg. C. is 25 per cent greater than that of ordinary steam, that it increases as the temperature rises, and that at a temperature of 300 deg. C. the deposit of moisture, which reduces the weight of the ordinary steam in the cylinders by one-third, is avoided.

The most recent trial that an engine equipped with the Schmidt superheater has undergone was at the high-speed steam locomotive tests made on the track between Marienfelde and Zossen, when an engine built by the Borsig firm and equipped with a Schmidt superheater made a speed of 128 kilometers (79½ miles) with a full train of six cars, and a speed of 136 kilometers (84½ miles) an hour with a train of three cars, the energy developed being about 2,000 horse-power. The Borsig engine, unlike the three other engines, was not built specially for these trials, but only one of its competitors equaled it in speed.

Mr. Borsig, the head of the firm of A. Borsig, one of the most important steam engine factories in Germany, which has constructed about one-half of the locomotives equipped with the Schmidt superheater for the Prussian government, but which has no financial interest in that device, stated in a personal interview that in his opinion the Schmidt superheater has ceased to be an experiment; that its industrial value has been established. He also stated that the favorable showing of his engine at the high-speed trials at Zossen could not have been obtained if the Schmidt superheater had not been used.

While the Schmidt superheater has hardly been in use long enough to show just how great the wear and tear on the machinery owing to the use of superheated steam will be, the Prussian railroad officials are satisfied with the way in which the parts coming in contact with it have kept in order on the engines at present in service.

It is likely that the Schmidt superheater would have been adopted already on a much larger scale were it not for the opposition which it has encountered from the partisans of other superheaters. Encouraged by the success obtained by Schmidt, other inventors have taken up the same line of work and have produced superheaters of varying degrees of practicability. Of these the Pielock is the one that has received the most attention in this country, and would appear to be the most serious competitor to the Schmidt invention. It consists of a chamber or metal box located in the boiler, from which it is separated by a metal wall through which the boiler flues pass. The interior of the superheater is divided up by walls in such a manner that the steam in passing through the different sub-compartments is made to circulate along the boiler flues. Owing to the risk of injury to the flues, it has not been found desirable to place the superheater too close to the furnace. The temperature in the furnace flues is reduced by passing through the water of the boiler, and the temperature attained by the steam in the superheater is from 230 deg. to 260 deg. C.

As will be seen by the foregoing, there exists a radical difference between the Schmidt and Pielock superheaters. While in the former the steam is heated to from 300 deg. to 350 deg. C. by means of one large flue, which conveys part of the furnace gas to the superheater chamber, in the Pielock system all the furnace gas is passed through the superheater by means of the boiler flues, the steam being heated only from 230 deg. to 260 deg. C.

In all some ten engines have been or are to be equipped with the Pielock superheater by the Prussian State railroads, but it has not been possible to obtain satisfactory information as to the results recently obtained. Only old engines have been experimented with, one of the principal advantages of the Pielock over the Schmidt superheater being that old engines can be equipped with it without expensive alterations. In order to equip an engine with a Schmidt superheater capable of giving the steam a high temperature it is necessary to enlarge the smoke box in order to make room for the superheater, and in case the superheater is made smaller, the old smoke box being retained, it is possible to obtain only moderate temperatures, similar to those obtained by the Pielock system.

The Saxon and Austrian government railroads are also experimenting on a small scale with the Pielock superheater, the rights to which have been acquired by the Maschinenbau Actien Gesellschaft at Hanover, but the only official tests of engines provided with it that have been made public took place on the track between Breslau and Glogau, where the work done by two engines with superheaters and two similar ones without them was compared, each engine making ten trips over the same track on alternate days. One of the Pielock engines attained an economy of 14.7 per cent in coal and 18 per cent in water, while the economy achieved by the other engine was far less important. It is understood that the results obtained since, which have not been made public, are very contradictory. In view of the many factors that are likely to influence tests of this kind, technical men are extremely conservative in accepting their results as conclusive, and it will probably take considerable time before the efficiency of the Pielock superheater will be satisfactorily demonstrated.

It is claimed for the Pielock superheater by its inventor that it can be used on old as well as new locomotives, as it can be adjusted to any boiler, and that no loss of power is entailed, as, owing to the greater efficiency of the superheated steam, the space taken up in the boiler is more than compensated for; that owing to the simplicity of construction of the Pielock superheater it is cheaper than any other type, costing from $450 to $600 only for a two to four-cylinder Prussian express locomotive; that with it there is no loss from radiation, as any heat lost in the superheater raises the temperature of the water in the boiler; that it is less subject to repair than any other superheater, and needs no special cleaning other than the cleaning of the boiler flues, which would have to take place anyway; and that no extra labor is entailed on the part of the locomotive engineer.

A long and somewhat acrid controversy has been carried on in the technical journals of Germany as to which of the rival systems is based on the right principle, and opinions vary widely as to the results obtained by them.

It is claimed by the adherents of the Schmidt system that it is impossible to obtain sufficient increase in efficiency with the moderate temperature attained by the Pielock superheater to justify its use; that frequent repairs to the furnace flues passing through the superheater will be inevitable; that they can not be examined without being taken out; that this involves serious damage to the superheater and to the walls to which they are made fast; and that a flue thus removed can not be used again.

The partisans of the Pielock system claim, on the other hand, that the large furnace flue used in the Schmidt system is likely to leak where it is connected with the superheater; that the highly superheated steam is very injurious to the machine parts which it comes in contact with; and that too much heat goes out of the smokestack.

Only a technical expert with ample opportunities for actual observation could form an opinion that would be of value as to the merit of these claims, but there can be no doubt that the Schmidt superheater has been far more thoroughly tested and that it has been used longer and more extensively than the Pielock device. In a ministerial decree of February 3, 1903, expert evidence as to whether moderately superheated steam could be employed advantageously in compound engines was called for, and a large amount of testimony bearing on the use of moderately superheated steam and, incidentally, on the advantages of the Schmidt and Pielock systems, was submitted, together with a report by an official committee of investigation which answered the various questions propounded by the ministerial decree. This report, which is exceedingly technical in character, is far too exhaustive to be embodied in a consular report, but contains some information and conclusions that are highly instructive. Much evidence was given as to the degree of concentration of steam necessary to prevent the deposit of water in the cylinders when moderately heated steam is used. According to some investigators this objectionable action occurs in the low-pressure cylinders of locomotives using steam of 250 deg. C., but no absolute conclusions were reached by the investigating committee. In answer to the question whether it was possible to obtain satisfactory economy of fuel and efficiency by using temperatures up to 250 deg. C., the report stated that the use of highly superheated steam, at 300 deg. C. and over, was necessary to high efficiency; that excellent results had been obtained by twin engines with steam at 300 deg. C., and that the decrease of coal consumed as the temperature was raised from 320 to 350 deg. C. was very remarkable. It was reported that the Schmidt superheater could be used satisfactorily for moderate temperatures, in which case its size could be reduced.

It was also reported that the use of auxiliary engines for upgrades had in different instances been obviated by the use of engines equipped with Schmidt superheaters. The report contained a very exhaustive examination of the evidence at hand as to the relative merits of two and four cylinders, the conclusion being drawn that four cylinders are not essential to smooth action. The continuation of investigations as to the efficiency of the Pielock superheater with compound engines was advised, it being reported that while economy was obtained by its use, no material increase of efficiency had been established. While it is possible that the Prussian railway experts may be favorably influenced toward the Schmidt superheater by the fact that its practical application has been developed under their auspices, and by the very considerable opportunity for observing it that they have enjoyed during the last six years, it is believed that the favorable nature of this report is entitled to very great weight. Far greater conservatism exists in Germany than in the United States about making expenditures for improvements the value of which has not been absolutely proved. It would seem very likely that the unbiased opinion of the manufacturer, Mr. Borsig, that the value of the Schmidt superheater has been demonstrated, is correct.

While differences of opinion may still exist as to what type of superheater is the best, the patient investigation and experiments that have been carried on in Germany have established the fact that superheated steam can be used with locomotives as well as with stationary engines. When the much greater efficiency of superheated over ordinary steam is taken into consideration there seems strong reason to believe that the success already obtained by the stationary engine will be repeated with the locomotive—that materially superior economy in power will be attained by the use of superheated steam, which will in time come into general use for locomotives.

So far as is known, there is only one locomotive using superheated steam in America, and it is equipped with a Schmidt superheater and is being experimented with by the Canadian-Pacific line. It is believed that it is well worth the while of American technical and railroad men to give careful consideration to the experience obtained by the Prussian State railroad in the utilization of superheated steam on locomotives, and to examine the locomotives equipped with the Schmidt and Pielock superheaters that are being exhibited at St. Louis.

The following literature is recommended to those desiring to make further investigations: Special Reports of Zeitschrift des Vereines deutscher Ingenieure; Die Anwendung von hochüberhitztem Dampf (Heissdampf) im Lokomotivebetriebe nach dem System von Wilhelm Schmidt in Wilhelmshöhe bei Cassel, by Garbe (Berlin, 1903); Zur Frage der Anwendung der Dampfüberhitzung im Lokomotivebetriebe, by Otto Berner (Berlin, 1903); Vergleichende Versuche mit gesättigtem und mässig überhitztem Dampf an Lokomotiven, by Strahl (Berlin, 1904); Consular Report of April 20, 1904, from Berlin, relative to high speed tests; and the article already mentioned in Eisenbahn Technik der Gegenwart of the year 1902. The first three reports may be obtained by writing to the Verein Deutscher Ingenieure, Monbijou Platz 3, Berlin.—Dean B. Mason, Vice and Deputy Consul-General, Berlin, Germany.

THE IRRIGATION DEVELOPMENT OF EGYPT—A HUGE PROJECT.

By the English Correspondent of the SCIENTIFIC AMERICAN.

A MOMENTOUS scheme for the irrigation of Egypt has been formulated by Sir William Garstin, the Under-Secretary of State for the Egyptian Public Works Department, and which when completed will constitute one of the greatest civil engineering achievements of the time, rivaling even the barrages recently completed across the River Nile at Aswan and Asyut.

For five years Sir William Garstin and his staff have been employed in a complete and exhaustive survey of the upper reaches of the Nile with a view to discovering the most practicable means of increasing the supply of water that can be brought down into Egypt, thereby rendering fertile thousands of acres of land which are at present arid and sterile owing to the absence of irrigation. Under existing conditions no less than 80 per cent of the vast quantity of water flowing from the lakes Victoria and Albert into the White Nile never reaches the lower country, simply because in its passage it has to flow through immense swamps between Lado and Fashoda, which merely absorb the water. Sir William Garstin's object, therefore, is to improve the channel of the White Nile in such a manner that it will add to the lower Nile flood, and also increase the flowing capacity of that tributary during the dry season. In the scheme he has so carefully prepared, a solution of this complex problem is advanced, and he also proposes to improve the Sudan, by the utilization of the waters of the Blue Nile.

The principal item in the scheme is to improve the channel of the White Nile, and for this purpose he proposes to divert its course through a canal to be specially cut to the eastward of the river's present course for a distance of 200 miles between Bor and the Sobat. The construction of this new waterway will result in the river avoiding the marsh country, which as the projector states, "has an aspect of desolation beyond the power of words to describe." Conjointly with this idea he proposes to erect barrages at the outlets of the lakes Victoria and Albert, so as to regulate the flow of water therefrom into the river channel.

This is a gigantic undertaking, which it would cost about $73,550,000 to realize, of which sum the construction of the canal would cost $26,000,000, and the construction of barrages between Asyut and Keneh, the regulation of the lakes and the perennial irrigation of Upper Egypt would consume the remainder of the outlay.

As an alternative to the diversion of the river, which might possibly be deemed too difficult or impracticable from the point of view of expense, he sets forth a scheme for the training of the channel known as the Bahr-el-Gebel, by damming the tributaries and planting ambatch trees at intervals for hundreds of miles. This task would involve approximately one-half of the cost of the former project, though it would not be perhaps so effective. In either event Sir William Garstin opines that the volume of water of the White Nile at Khartoum would be increased by 50 per cent.

The scheme for regulating the Blue Nile is no less vast. The regulation of the water would be carried out for several miles above Khartoum. The possibility of damming Lake Tsana, on the Abyssinian plateau, and converting it into a huge reservoir for Egypt's water supply, he abandons for political reasons. But he suggests the construction of a reservoir at Rosaires, the damming of the River Khash, which at present is practically dry during half the year, and a canal system in Chexireh for the irrigation of the extensive plain around Kassala.

Schemes are also advocated for the improvement of the Nile delta by the remodeling of the Rosietta and Damietta canal branches, together with the raising of the Aswan dam. This latter scheme, which it is proposed to take in hand first, will cost $7,000,000.

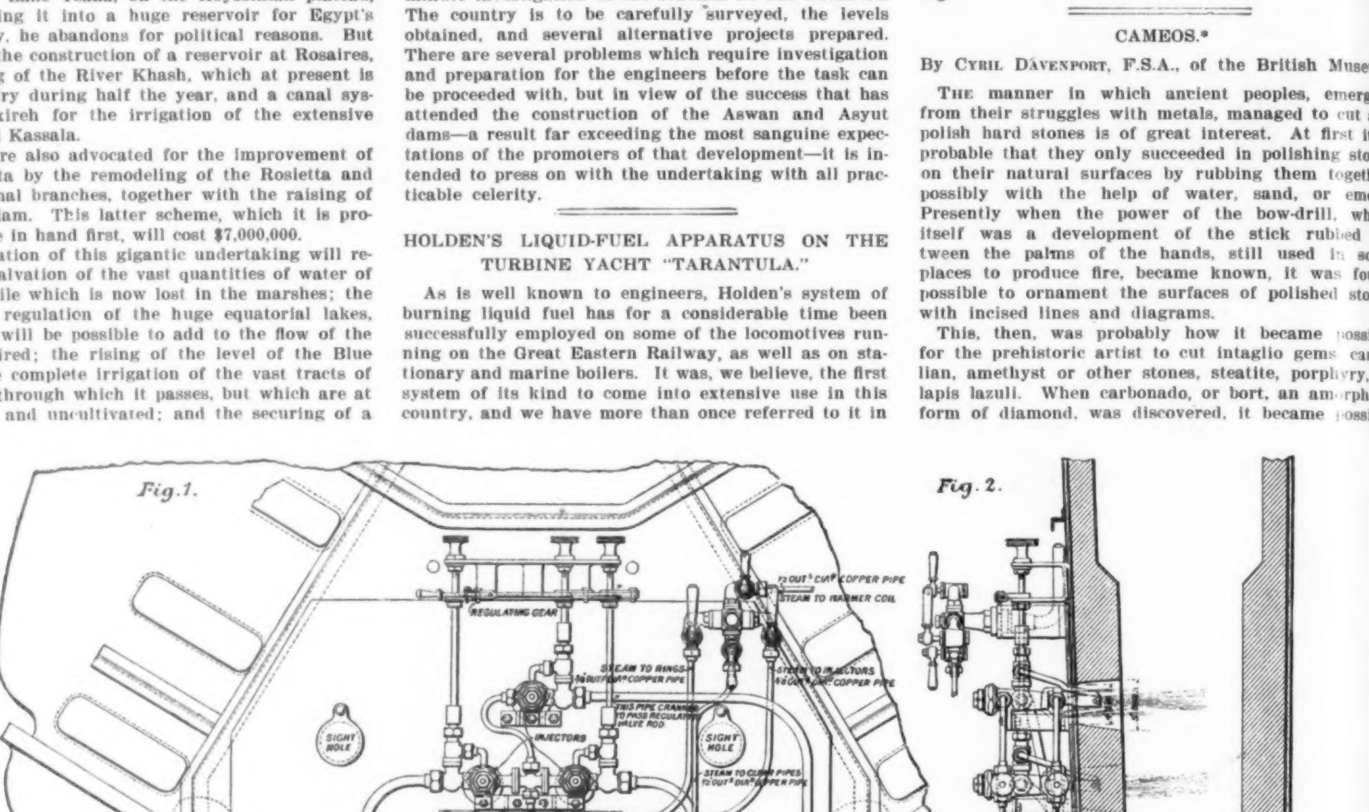
The realization of this gigantic undertaking will result in the salvation of the vast quantities of water of the White Nile which is now lost in the marshes; the control and regulation of the huge equatorial lakes, by which it will be possible to add to the flow of the river as desired; the rising of the level of the Blue Nile and the complete irrigation of the vast tracts of fertile land through which it passes, but which are at present arid and uncultivated; and the securing of a high cost, in preference to the alternative project of the Bahr-el-Gebel works.

There is no doubt that the realization of these schemes would prove of inestimable benefit to the country. In fact, so far as the Sudan country is concerned, Lord Cromer asserts that its prosperity can only be assured by extensive irrigation. The cost of the work will not prove a heavy drain upon the financial resources of the country, since the increase of the land revenue, even under moderate taxation, will approximate $6,025,000 per annum. It will thus be realized that in comparatively few years the outlay would be recouped.

Sir William Garstin is now proceeding with a more minute investigation of the schemes he has advanced. The country is to be carefully surveyed, the levels obtained, and several alternative projects prepared. There are several problems which require investigation and preparation for the engineers before the task can be proceeded with, but in view of the success that has attended the construction of the Aswan and Asyut dams—a result far exceeding the most sanguine expectations of the promoters of that development—it is intended to press on with the undertaking with all practicable celerity.

HOLDEN'S LIQUID-FUEL APPARATUS ON THE TURBINE YACHT "TARANTULA."

As is well known to engineers, Holden's system of burning liquid fuel has for a considerable time been successfully employed on some of the locomotives running on the Great Eastern Railway, as well as on stationary and marine boilers. It was, we believe, the first system of its kind to come into extensive use in this country, and we have more than once referred to it in



LIQUID FUEL APPARATUS ON THE TURBINE YACHT "TARANTULA."

our columns. As originally designed by Mr. Holden, it was intended to be used as a means of utilizing the tars produced by the oil-gas apparatus at the Stratford works of the Great Eastern Railway Company; but it has since been used with many kinds of liquid fuels, such as coal tar, blast-furnace tar, and oil, shale oil, creosote and green oil, astatki, and crude petroleum. When used on the Great Eastern Railway, a thin fire is made up on the bars, with coal and about 1 hundredweight of broken chalk, and the ashpit damper is kept sufficiently open to keep the fire bright. Two holes, about 5 inches in diameter, are made in the front plates of the fire-box, about 10 inches above the grate, and about 1 foot 9 inches apart from center to center. A ring of perforated pipe is placed in each of these holes, with the perforations facing toward the inside of the fire-box. Through these pipes steam from the boiler flows, and passes into the fire-box in the form of numerous fine jets, which cause an induced current of air. The oil is sprayed into the fire-box by means of a steam-worked injector, the nozzle of which is fixed in the center of the perforated ring. The steam, as it passes in, is mixed with air, which enters at the rear of the injector.

The system as used on the Great Eastern Railway for locomotives has, of course, to be somewhat modified when applied to stationary and marine boilers. Figs. 1, 2, and 3 show the apparatus as recently supplied by Messrs. Taite & Carlton, 63 Queen Victoria Street, London, for two Yarrow boilers on board Mr. W. K. Vanderbilt, Jr.'s, turbine yacht "Tarantula." Each boiler has a grate area of 33 square feet, and is capable of developing 2,000 to 2,200 horse-power. The arrangement of the injector, pipes, etc., will, we think, be readily understood on reference to the illustrations, where Fig. 1 is a front elevation, Fig. 2 a section through the center of the boiler, and Fig 3 a plan. The injectors are three in number, and are placed in the form of an equilateral triangle, as shown. The pipe leading from the fuel tank may be seen running horizontally along the lower part of the boiler front, and from it branch pipes are taken to the various injectors. The regulating gear for the oil is conveniently placed in the center of the boiler front just above the injectors, where it can be very easily reached, while the cocks for regulating the steam supply may be seen somewhat to the right. A ⅛-inch copper pipe for steam is led down from the fitting that regulates the supply of steam to the injectors, this being for use in clearing out the fuel-pipe when required.—Engineering.

constant and sufficient supply for the entire area between the Cataracts and the Mediterranean; while it will also release the Sudan from the ever-existing danger of disastrous floods.

The total cost of the undertaking would be approximately $110,000,000 and the work would occupy from ten to fifteen years to complete. In addition to this outlay, however, the development of the railroad is imperative partially for the assistance of the construction of the irrigation works, and as the expense on this item is estimated at $20,000,000, the aggregate outlay would be about $130,000,000.

The estimated result of these works would be the fertilization of 1,600,000 acres of land which is at present only desert. Water will be available all the year round for 750,000 acres, which at present are only partially supplied. Another 100,000 acres will be irrigated by pumps, and 800,000 acres of absolutely sterile land will be rendered possible for cultivation by rich alluvial deposits.

Lord Cromer fully indorses Sir William Garstin's schemes, but owing to the magnitude of the undertaking and the enormous outlay it entails, he proposes its realization by degrees. One of his first projects, however, is to complete the Suakim-Berber Railroad, which, it is anticipated, will be accomplished by the spring of 1906. This would be followed by the damming of the River Gash and the irrigation of the Kassala plain, which would bring the 100,000 additional acres of land under cultivation at an approximate cost of $25 per acre. The realization of this project alone would result in an annual addition to the revenue from land tax of some $250,000.

In connection with the development of the White Nile, Lord Cromer is in favor of the construction of the 200-mile canal, notwithstanding its magnitude and

CAMEOS.*

By CYRIL DAVENPORT, F.S.A., of the British Museum.

THE manner in which ancient peoples, emerging from their struggles with metals, managed to cut and polish hard stones is of great interest. At first it is probable that they only succeeded in polishing stones on their natural surfaces by rubbing them together, possibly with the help of water, sand, or emery. Presently when the power of the bow-drill, which itself was a development of the stick rubbed between the palms of the hands, still used in some places to produce fire, became known, it was found possible to ornament the surfaces of polished stones with incised lines and diagrams.

This, then, was probably how it became possible for the prehistoric artist to cut intaglio gems carnelian, amethyst or other stones, steatite, porphyry, or lapis lazuli. When carbonado, or bort, an amorphous form of diamond, was discovered, it became possible to cut and polish hard stones with comparative ease and rapidity, and also the invention of the treadle drill, working sideways, in contradistinction to the bow drill, which only works downward, made it possible for the first time to cut designs with proper control upon hard stones. Bort when powdered is as effective as diamond dust to cut and polish stones, even the diamond itself, and now machines of such power and accuracy are made that the faceting of a diamond, for instance, is not so difficult as it formerly was; but the cutting of a gem, although it can now be done quickly, is still a matter requiring the utmost skill, as the gem is held in the cutter's hand and pressed against the rapidly-revolving point, armed with diamond dust and oil. The point is of soft iron formed like the head of a pin.

The polishing of an engraved gem is done in the same way, but with softer materials; the points may be of lead, ivory, or copper, and the oil is usually mixed with tripoli powder, rotten stone, crocus, rouge, or putty powder; but for the diamond or some other very hard stones, diamond dust must still be used.

Repolishing of antique gems, both intaglio and cameo, was much practised during the Renaissance, when gem cutters of all kinds were extremely skillful. Such repolishing is unfortunately always harmful, as the original engravers in fact finished their engraving by means of the polishing, so that any further work done on the same grounds tends to deterioration.

* Substance of a lecture delivered before the Royal Institution of Great Britain on April 23, 1904. The lecture was illustrated by fifty lantern slides taken directly from the objects themselves, and colored by the lecturer in a manner invented by himself. The Times report said that these slides were so fine that to use them was like looking at the gems themselves, magnified.

Where the earliest cameos were made will always be a matter of conjecture. All I can say is that as far as I know there exist cameo engravings in low relief on shells and eggs which may have been done so long ago that to suggest any date would be imprudent. But for really skilled work we need not go further back than to the Egyptian Scarabæi, which were seals with the backs cut into the semblance of the sacred beetle. I may here say in passing that the outline of the scarab cameo persisted for a very long time, gems of this shape being known as scaraboids.

The cameo scarabs are cut in carnelian, hematite, basalt, steatite, and many other substances, and they are also made in porcelain, often glazed, as are also several of the stone examples. At Mycenæ a small seal of amethyst with the back cut into the semblance of a lion dormant was found; and in the British Museum is a small sardonyx of Greek workmanship signed "Syrias," on the back of which is a satyr cut in cameo. This, as well as one showing a sphinx, is in the Cabinet des Medailles in Paris, and both of these are attributed to about the sixth century B. C.

Signatures on cameos read the right way about, whereas on intaglios they are reversed. If a signature on an onyx cameo shows in relief and corresponds in color with the part of the cameo in relief, it is probably contemporary work, but if it is only cut in intaglio on the groundwork it may have been fraudulently added.

The two finest double-head cameos in the world are the Gouzaga cameo at the Hermitage Museum in St. Petersburg, and the Vienna cameo. Both these gems are of Ptolemaic times, and are supposed to represent Ptolemy II. Philadelphus and his two successive wives, each named Arsinoë. Ptolemy reigned during the third century B. C., and the workmanship of the cameos may be considered as Græco-Egyptian. Of the same period and style is the remarkable Tazza Farnese now at Naples.

Between the Ptolemaic cameos and those of the period of the Roman empire there is a paucity of work in cameo. The Ptolemaic cameos are the first to show that gem engravers of cameos appreciated the singular fitness of the onyx stone, with its concurrent layers of stone of different colors, for such work Indeed it may well be said the cameos had no existence as an art subject of themselves until the use of the onyx was understood. Cameos are of course cut in numbers of other materials—bloodstone, carnelian, corundum, amethyst, rock-crystal, and the like—but in all cases they were expensive and slow to produce. Like all fashionable cults, even to-day, the fashion set by the upper classes of society gradually filters downward, and so we find that the lesser Romans contented themselves with molded glass cameos, called pastes, instead of the finer carvings worn by the rich Patricians. The Roman pastes of the first and second centuries before Christ are now, however, of much value, and several of them are really fine. They are made in the same manner that James Tassie made his in after years, cast in molds taken from actual gems. But in some few cases glass was actually cut in the same way as if it were stone. The finest example of this is the exquisite Portland vase, now deposited in the British Museum, but the property of the Duke of Portland. It is of dark-blue glass, dipped in white, and then the white is cut away down to the blue ground exactly as it would be in the case of an onyx. Besides this vase there is in the British Museum the Auldjo vase, with a wreath in white, and the Vase des Vaudauges at Naples, and numbers of fragments in most large museums.

The great period of cameo cutting was that of the emperor Augustus, during the first century of the Christian era, as well as the Roman empire. Augustus himself loved cameos, and the finest single head cameo in the world shows his head wearing a jeweled tiara. The Græco-Roman cameos, all cut by Greeks, when not portraits, are designed in the classical manner, and they were produced until the fourth century, when Constantine the Great left Rome and went to Byzantium to found the new empire. Byzantine art then usurped the first place, and whenever possible altered the classical designs into Christian ones. Hercules becomes David, the attributes being changed as well as possible; Jupiter, with his eagle, does duty for St. John; "Perseus and the Gorgon" are christened "David and Goliath;" Venus and Leda change their usual characters and turn into the Virgin Mary, and the head of Medusa becomes the sacred face of St. Veronica.

Until the Renaissance in the late fifteenth and sixteenth centuries, these Christian motives remained unchanged, and then once more a general change occurred, and there was a universal return to classical themes.

The Renaissance work is technically quite as fine as the antique, but there was a want of originality, and no doubt the Renaissance workers employed their skill in making fraudulent copies and touching up worn or inferior antiques. There is no golden rule by which to recognize an antique cameo from one made during the Renaissance.

It may, however, be noted that antiques generally have small margins, whereas Renaissance gems often have broad margins. Antiques are polished all over, later work often shows polish only in places. The backs of antique gems are often rounded, whereas Renaissance gems are almost always flat.

A cameo is one of the most lasting forms of art. Time affects it but little; damp not at all; light not at all. It is the product of the highest skill in art, and owes none of its beauty to chance except simply the color of the stone. Moreover a fine cameo is of great price. If rich men could be induced to have their portraits cut in fine onyx cameos they would render themselves as immortal as Ptolemy II. did when he had himself and his wife cut in the beautiful onyx which is as fine and clear to-day as it was some twenty-two centuries ago! No painting can approach such a work of art in permanence, and as many judges would say, even in beauty.

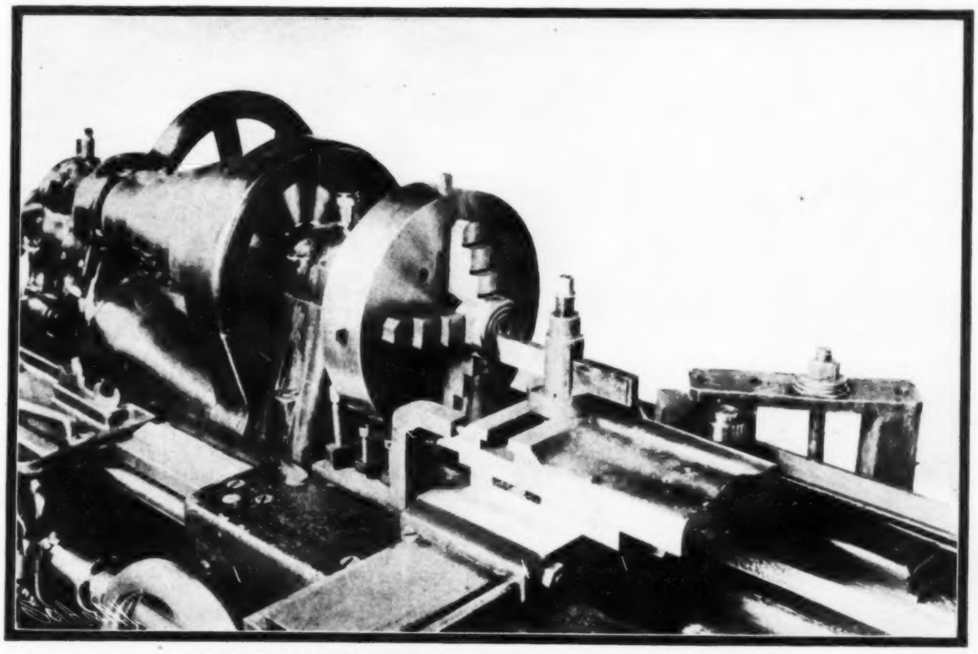
A SPIRAL SCREW CUTTING ARRANGEMENT FOR LATHES.*

By J. S. GEORGE.

THE accompanying photograph of a 14-inch P. W. lathe shows a method of cutting a spiral screw 4 per inch pitch that may perhaps be not without interest to readers of this journal.

As the cross slide is not positively connected with the lead screw it is impossible to cut a spiral. In order to secure the use of the lead screw, I planed a 45-degree block fitting in the groove of the taper attachment on the end of the lower slide, and put a roller in position to abut against the 45-degree-angle side of the block. Then I clamped the double-angle stop on the bed having an adjusting screw on the end, to work up against the compound rest slide. Removing the screw of the compound rest, and turning it around so that it will slide parallel with the bed of the lathe, I set the lathe to the spiral to be cut. The roller thus engaged the 45-degree block to give the cross movement. At the same time the carriage moved along the same distance. The stop that worked against the compound rest prevented the slide from being carried forward, but allowed it to move parallel with the face of the work. To get a cut for the tool I moved the adjusting screw and held the compound rest slide up against the screw by hand. The operation was easily done, as the slide tended to move forward.

A number of spirals have been cut in this way and all have been found correct.



SPIRAL SCREW-CUTTING ARRANGEMENT FOR LATHES.

REFLECTIONS SUGGESTED BY THE NEW THEORY OF MATTER.†

By the Right Hon. A. J. BALFOUR, D.C.L., LL.D., M.P. F.R.S., Chancellor of the University of Edinburgh.

THE meetings of this great society have for the most part been held in crowded centers of population, where our surroundings never permit us to forget, were such forgetfulness in any case possible, how close is the tie that binds modern science to modern industry, the abstract researches of the student to the labors of the inventor and the mechanic. This, no doubt, is as it should be. The interdependence of theory and practice cannot be ignored without inflicting injury on both; and he is but a poor friend to either who undervalues their mutual co-operation.

Yet, after all, since the British Association exists for the advancement of science, it is well that now and again we should choose our place of gathering in some spot where science rather than its applications, knowledge, not utility, are the ends to which research is primarily directed.

If this be so, surely no happier selection could have been made than the quiet courts of this ancient university. For here, if anywhere, we tread the classic ground of physical discovery. Here, if anywhere, those who hold that physics is the true *scientia scientiarum*, the root of all the sciences which deal with inanimate nature, should feel themselves at home. For, unless I am led astray by too partial an affection for my own university, there is nowhere to be found, in any corner of the world, a spot with which have been connected, either by their training in youth, or by the labors of their maturer years, so many men eminent as the originators of new and fruitful physical conceptions. I say nothing of Bacon, the eloquent prophet of a new era; nor of Darwin, the Copernicus of biology; for my subject to-day is not the contributions of Cambridge to the general growth of scientific knowledge. I am concerned rather with the illustrious line of physicists who have learned or taught within a few hundred yards of this building—a line stretching from Newton in the seventeenth century, through Cavendish in the eighteenth, through Young, Stokes, Maxwell, in the nineteenth; through Kelvin, who embodies an epoch in himself, down to Rayleigh, Larmor, J. J. Thomson, and the scientific school centered in the Cavendish laboratory, whose physical speculations bid fair to render the closing years of the old century and the opening years of the new was notable as the greatest which have preceded them.

Now what is the task which these men, and their illustrious fellow-laborers out of all lands, have set themselves to accomplish? To what end led these "new and fruitful physical conceptions" to which I have just referred? It is often described as the discovery of the "laws connecting phenomena." But this is certainly a misleading, and in my opinion a very inadequate, account of the subject. To begin with, it is not only inconvenient, but confusing, to describe as "phenomena" things which do not appear, which never have appeared, and which never can appear, to beings so poorly provided as ourselves with the apparatus of sense perception. But apart from this, which is a linguistic error too deeply rooted to be easily exterminated, is it not most inaccurate in substance to say that a knowledge of Nature's laws is all we seek when investigating Nature? The physicist looks for something more than what, by any stretch of language, can be described as "co-existences" and "sequences" between so-called "phenomena." He seeks for something deeper than the laws connecting possible objects of experience. His object is physical reality: a reality which may or may not be capable of direct perception; a reality which is in any case independent of it; a reality which constitutes the permanent mechanism of that physical universe with which our immediate empirical connection is so slight and so deceptive. That such a reality exists, though philosophers have doubted, is the unalterable faith of science; and were that faith *per impossibile* to perish under the assaults of critical speculation, science, as men of science usually conceive it, would perish likewise.

If this be so, if one of the tasks of science, and more particularly of physics, is to frame a conception of the physical universe in its inner reality, then any attempt to compare the different modes in which, at different epochs of scientific development, this intellectual picture has been drawn, cannot fail to suggest questions of the deepest interest. True, I am precluded from dealing with such of these questions as are purely philosophical by the character of this occasion; and with such of them as are purely scientific by my own incompetence. But some there may be sufficiently near the dividing line to induce the specialists who rule by right on either side of it to view with forgiving eyes any trespasses into their legitimate domain which I may be tempted, during the next few minutes, to commit.

Let me, then, endeavor to compare the outlines of two such pictures, of which the first may be taken to represent the views prevalent toward the end of the eighteenth century; a little more than a hundred years from the publication of Newton's "Principia," and roughly speaking, about midway between that epoch-making date and the present moment. I suppose that

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

† Address delivered before the British Association for the Advancement of Science.

if at that period the average man of science had been asked to sketch his general conception of the phyhical universe, he would probably have said that it essentially consisted of various sorts of ponderable matter, scattered in different combinations through space, exhibiting most varied aspects under the influence of chemical affinity and temperature, but through every metamorphosis obedient to the laws of motion, always retaining its mass unchanged, and exercising at all distances a force of attraction on other material masses, according to a simple law. To this ponderable matter he would (in spite of Rumford) have probably added the so-called "imponderable" heat, then often ranked among the elements; together with the two "electrical fluids," and the corpuscular emanations supposed to constitute light.

In the universe as thus conceived, the most important forms of action between its constituents was action at a distance; the principle of the conservation of energy was, in any general form, undreamed of; electricity and magnetism, though already the subjects of important investigation, played no great part in the whole of things; nor was a diffused ether required to complete the machinery of the universe.

Within a few months, however, of the date assigned for these deliverances of our hypothetical physicist, came an addition to this general conception of the world, destined profoundly to modify it. About a hundred years ago Young opened, or re-opened, the great controversy which finally established the undulatory theory of light, and with it a belief in an interstellar medium by which undulations could be conveyed. But this discovery involved much more than the substitution of a theory of light which was consistent with the facts for one which was not; since here was the first authentic introduction* into the scientific world-picture of a new and prodigious constituent—a constituent which has altered, and is still altering the whole balance (so to speak) of the composition. Unending space, thinly strewn with suns and satellites, made or in the making, supplied sufficient material for the mechanism of the heavens as conceived by Laplace. Unending space filled with a continuous medium was a very different affair, and gave promise of strange developments. It could not be supposed that the ether, if its reality were once admitted, existed only to convey through interstellar regions the vibrations which happen to stimulate the optic nerve of man. Invented originally to fulfill this function, to this it could never be confined. And accordingly, as everyone now knows, things which, from the point of view of sense perception, are as distinct as light and radiant heat, and things to which sense perception makes no response, like the electric waves of wireless telegraphy,† intrinsically differ, not in kind, but in magnitude alone.

This, however, is not all, nor nearly all. If we jump over the century which separates 1804 from 1904, and attempt to give in outline the world-picture as it now presents itself to some leaders of contemporary speculation, we shall find that in the interval it has been modified, not merely by such far-reaching discoveries as the atomic and molecular composition of ordinary matter, the kinetic theory of gases, and the laws of the conservation and dissipation of energy, but by the more and more important part which electricity and the ether occupy in any representation of ultimate physical reality.

Electricity was no more to the natural philosophers in the year 1700 than the hidden cause of an insignificant phenomenon.‡ It was known, and had long been known, that such things as amber and glass could be made to attract light objects brought into their neighborhood; yet it was about fifty years before the effects of electricity were perceived in the thunderstorm. It was about 100 years before it was detected in the form of a current. It was about 120 years before it was connected with magnetism; about 170 years before it was connected with light and ethereal radiation.

But to-day there are those who regard gross matter, the matter of every-day experience, as the mere appearance of which electricity is the physical basis; who think that the elementary atom of the chemist, itself far beyond the limits of direct perception, is but a connected system of monads or sub-atoms which are not electrified matter, but are electricity itself; that these systems differ in the number of monads which they contain, in their arrangement, and in their motion relative to each other and to the ether; that on these differences, and on these differences alone, depend the various qualities of what have hitherto been regarded as indivisible and elementary atoms; and that while in most cases these atomic systems may maintain their equilibrium for periods which, compared with such astronomical processes as the cooling of a sun, may seem almost eternal, they are not less obedient to the law of change than the everlasting heavens themselves.

But if gross matter be a grouping of atoms, and if atoms be systems of electrical monads, what are these electrical monads? It may be that, as Prof. Larmor has suggested, they are but a modification of the universal ether, a modification roughly comparable to a knot in a medium which is inextensible, incompressible, and continuous. But whether this final unification be accepted or not, it is certain that these monads cannot be considered apart from the ether. It is on their interaction with the ether that their qualities depend; and without the ether an electric theory of matter is impossible.

* The hypothesis of an ether was, of course, not new. But before Young and Fresnel it cannot be said to have been established.

† First known through the theoretical work of Maxwell and the experiments of Herz.

‡ The modern history of electricity begins with Gilbert, but I have throughout confined my observations to the post-Newtonian period.

Surely we have here a very extraordinary revolution. Two centuries ago electricity seemed but a scientific toy. It is now thought by many to constitute the reality of which matter is but the sensible expression. It is but a century ago that the title of an ether to a place among the constituents of the universe was authentically established. It seems possible now that it may be the stuff out of which that universe is wholly built. Nor are the collateral inferences associated with this view of the physical world less surprising. It used, for example, to be thought that mass was an original property of matter, neither capable of explanation nor requiring it; in its nature essentially unchangeable, suffering neither augmentation nor diminution under the stress of any forces to which it could be subjected; unalterably attached to, or identified with, each material fragment, howsoever much that fragment might vary in its appearance, its bulk, its chemical or its physical conditions.

But if the new theories be accepted these views must be revised. Mass is not only explicable, it is actually explained. So far from being an attribute of matter considered in itself, it is due, as I have said, to the relation between the electrical monads of which matter is composed and the ether in which they are bathed. So far from being unchangeable, it changes, when moving at very high speeds, with every change in its velocity.

Perhaps, however, the most impressive alteration in our picture of the universe required by these new theories is to be sought in a different direction. We have all, I suppose, been interested in the generally accepted views as to the origin and development of suns with their dependent planetary systems; and the gradual dissipation of the energy which during this process of concentration has largely taken the form of light and radiant heat. Follow out the theory to its obvious conclusions and it becomes plain that the stars now visibly incandescent are those in mid-journey between the nebulæ from which they sprang and the frozen darkness to which they are predestined. What, then, are we to think of the invisible multitude of the heavenly bodies in which this process has been already completed? According to the ordinary view, we should suppose them to be in a state where all possibilities of internal movement were exhausted. At the temperature of interstellar space their constituent elements would be solid and inert; chemical action and molecular movement would be alike impossible, and their exhausted energy could obtain no replenishment unless they were suddenly rejuvenated by some celestial collision, or traveled into other regions warmed by newer suns.

This view must, however, be profoundly modified if we accept the electric theory of matter. We can then no longer hold that if the internal energy of a sun were as far as possible converted into heat either by its contraction under the stress of gravitation or by chemical reactions between its elements, or by any other inter-atomic force; and that, were the heat so generated to be dissipated, as in time it must be, through infinite space, its whole energy would be exhausted. On the contrary, the amount thus lost would be absolutely insignificant compared with what remained stored up within the separate atoms. The system in its corporate capacity would become bankrupt—the wealth of its individual constituents would be scarcely diminished. They would lie side by side, without movement, without chemical affinity; yet each one, howsoever inert in its external relations, the theatre of violent motions, and of powerful internal forces.

Or, put the same thought in another form. When the sudden appearance of some new star in the telescopic field gives notice to the astronomer that he, and perhaps, in the whole universe, he alone, is witnessing the conflagration of a world, the tremendous forces by which this far-off tragedy is being accomplished must surely move his awe. Yet not only would the members of each separate atomic system pursue their relative course unchanged, while the atoms themselves were thus riven violently apart in flaming vapor, but the forces by which such a world is shattered are really *negligeable* compared with those by which each atom of it is held together.

In common, therefore, with all other living things, we seem to be practically concerned chiefly with the feebler forces of Nature, and with energy in its least powerful manifestations. Chemical affinity and cohesion are on this theory no more than the slight residual effects of the internal electrical forces which keep the atom in being. Gravitation, though it be the shaping force which concentrates nebulæ into organized systems of sums and satellites, is trifling compared with the attractions and repulsions with which we are familiar between electrically charged bodies; while these again sink into insignificance beside the attractions and repulsions between the electric monads themselves. The irregular molecular movements which constitute heat, on which the very possibility of organic life seems absolutely to hang, and in whose transformations applied science is at present so largely concerned, cannot rival the kinetic energy stored within the molecules themselves. This prodigious mechanism seems outside the range of our immediate interests. We live, so to speak, merely on its fringe. It has for us no promise of utilitarian value. It will not drive our mills; we cannot harness it to our trains. Yet not less on that account does it stir the intellectual imagination. The starry heavens have from time immemorial moved the worship or the wonder of mankind. But if the dust beneath our feet be indeed compounded of innumerable systems, whose elements are ever in the most rapid motion, yet retain through uncounted ages their equilibrium unshaken, we can hardly deny that the marvels we directly see are not more worthy of admiration than those which recent discoveries have enabled us dimly to surmise.

Now, whether the main outlines of the world-picture which I have just imperfectly presented to you be destined to survive, or whether in their turn they are to be obliterated by some new drawing on the scientific palimpsest, all will, I think, admit that so bold an attempt to unify physical nature excites feelings of the most acute intellectual gratification. The satisfaction it gives is almost æsthetic in its intensity and quality. We feel the same sort of pleasurable shock as when from the crest of some melancholy pass we first see far below us the sudden glories of plain, river, and mountain. Whether this vehement sentiment in favor of a simple universe has any theoretical justification I will not venture to pronounce. There is no *a priori* reason that I know of for expecting that the material world should be a modification of a single medium, rather than a composite structure built out of sixty or seventy elementary substances, eternal and eternally different. Why, then, should we feel content with the first hypothesis and not with the second? Yet so it is. Men of science have always been restive under the multiplication of entities. They have eagerly noted any sign that the chemical atom was composite, and that the different chemical elements had a common origin. Nor, for my part, do I think such instincts should be ignored. John Mill, if I rightly remember, was contemptuous of those who saw any difficulty in accepting the doctrine of "action at a distance." So far as observation and experiment can tell us, bodies do actually influence each other at a distance. And why should they not? Why seek to go behind experience in obedience to some *a priori* sentiment for which no argument can be adduced? So reasoned Mill, and to his reasoning I have no reply. Nevertheless, we cannot forget that it was to Faraday's obstinate disbelief in "action at a distance" that we owe some of the crucial discoveries on which both our electric industries and the electric theory of matter are ultimately founded; while at this very moment physicists, however baffled in the quest for an explanation of gravity, refuse altogether to content themselves with the belief, so satisfying to Mill, that it is a simple and inexplicable property of masses acting on each other across space.

These obscure intimations about the nature of reality deserve, I think, more attention than has yet been given to them. That they exist is certain; that they modify the indifferent impartiality of pure empiricism can hardly be denied. The common notion that he who would search out the secrets of Nature must humbly wait on experience, obedient to its slightest hint, is but partly true. This may be his ordinary attitude; but now and again it happens that observation and experiment are not treated as guides to be meekly followed, but as witnesses to be broken down in cross-examination. Their plain message is disbelieved, and the investigating judge does not pause until a confession in harmony with his preconceived ideas has, if possible, been wrung from their reluctant evidence.

This proceeding needs neither explanation nor defense in those cases where there is an apparent contradiction between the utterances of experience in different connections. Such contradictions must of course be reconciled, and science cannot rest until the reconciliation is effected. The difficulty really arises when experience apparently says one thing and scientific instinct persists in saying another. Two such cases I have already mentioned; others will easily be found by those who care to seek. What is the origin of this instinct, and what its value; whether it be a mere prejudice to be brushed aside, or a clue which no wise man would disdain to follow, I cannot now discuss. For other questions there are, not new, yet raised in an acute form by these most modern views of matter, on which I would ask your indulgent attention for yet a few moments.

That these new views diverge violently from those suggested by ordinary observation is plain enough. No scientific education is likely to make us, in our unreflective moments, regard the solid earth on which we stand, or the organized bodies with which our terrestrial fate is so intimately bound up, as consisting wholly of electric monads very sparsely scattered through the spaces which these fragments of matter are, by a violent metaphor, described as "occupying." Not less plain is it that an almost equal divergence is to be found between these new theories and that modification of the common-sense view of matter with which science has in the main been content to work.

What was this modification of common sense? It is roughly indicated by an old philosophic distinction drawn between what were called the "primary" and the "secondary" qualities of matter. The primary qualities, such as shape and mass, were supposed to possess an existence quite independent of the observer; and so far the theory agreed with common sense. The secondary qualities, on the other hand, such as warmth and color, were thought to have no such independent existence, being, indeed, no more than the resultants due to the action of the primary qualities on our organs of sense-perception; and here, no doubt, common sense and theory parted company.

You need not fear that I am going to drag you into the controversies with which this theory is historically connected. They have left abiding traces on more than one system of philosophy. They are not yet solved. In the course of them the very possibility of an independent physical universe has seemed to melt away under the solvent powers of critical analysis.

But with all this I am not now concerned. I do not propose to ask what proof we have that an external world exists, or how, if it does exist, we are able to obtain cognizance of it. These may be questions very proper to be asked by philosophy; but they are not proper questions to be asked by science. For, logically, they are antecedent to science, and we must reject the skeptical answers to both of them before physical science becomes possible at all. My present purpose requires me to do no more than observe that, be this theory of the primary and secondary qualities of matter good or bad, it is the one on which science has in the main proceeded. It was with matter thus conceived that Newton experimented. To it he applied his laws of motion; of it he predicated universal gravitation. Nor was the case greatly altered when science became as much preoccupied with the movements of molecules as it was with those of planets. For molecules and atoms, whatever else might be said of them, were at least pieces of matter, and, like other pieces of matter, possessed those "primary" qualities supposed to be characteristic of all matter, whether found in large masses or in small.

But the electric theory which we have been considering carries us into a new region altogether. It does not confine itself to accounting for the secondary qualities by the primary, or the behavior of matter in bulk by the behavior of matter in atoms; it analyzes matter, whether molar or molecular, into something which is not matter at all. The atom is now no more than the relatively vast theatre of operations in which minute monads perform their orderly evolutions; while the monads themselves are not regarded as units of matter, but as units of electricity; so that matter is not merely explained, but is explained away.

Now the point to which I desire to call attention is not to be sought in the great divergence between matter as thus conceived by the physicist and matter as the ordinary man supposes himself to know it, between matter as it is perceived and matter as it really is, but to the fact that the first of these two quite inconsistent views is wholly based on the second.

This is surely something of a paradox. We claim to found all our scientific opinions on experience; and the experience on which we found our theories of the physical universe is our sense-perception of that universe. That is experience; and in this region of belief there is no other. Yet the conclusions which thus profess to be entirely founded upon experience are to all appearance fundamentally opposed to it; our knowledge of reality is based upon illusion, and the very conceptions we use in describing it to others, or in thinking of it ourselves, are abstracted from anthropomorphic fancies, which science forbids us to believe and Nature compels us to employ.

We here touch the fringe of a series of problems with which inductive logic ought to deal, but which that most unsatisfactory branch of philosophy has systematically ignored. This is no fault of men of science. They are occupied in the task of making discoveries, not in that of analyzing the fundamental presuppositions which the very possibility of making discoveries implies. Neither is it the fault of transcendental metaphysicians. Their speculations flourish on a different level of thought; their interest in a philosophy of nature is lukewarm; and howsoever the questions in which they are chiefly concerned be answered, it is by no means certain that the answers will leave the humbler difficulties at which I have hinted either nearer to or further from a solution. But though men of science and idealists stand acquitted, the same can hardly be said of empirical philosophers. So far from solving the problem, they seem scarcely to have understood that there was a problem to be solved. Led astray by a misconception to which I have already referred; believing that science was concerned only with (so-called) "phenomena," that it had done all that it could be asked to do if it accounted for the sequence of our individual sensations, that it was concerned only with the "laws of Nature," and not with the inner character of physical reality; disbelieving, indeed, that any such physical reality does in truth exist; it has never felt called upon seriously to consider what are the actual methods by which science attains its results, and how those methods are to be justified. If any one, for example, will take up Mill's logic, with its "sequences and co-existences between phenomena," its "method of difference," its "method of agreement," and the rest; if he will then compare the actual doctrines of science with this version of the mode in which those doctrines have been arrived at, he will soon be convinced of the exceedingly thin intellectual fare which has been hitherto served out to us.

There is an added emphasis given to these reflections by a train of thought which has long interested me, though I acknowledge that it never seems to have interested any one else. Observe, then, that in order of logic sense-perceptions supply the premises from which we draw all our knowledge of the physical world. It is they which tell us there is a physical world; it is on their authority that we learn its character. But in order of causation they are effects due (in part) to the constitution of our organs of sense. What we see depends not merely on what there is to be seen, but on our eyes. What we hear depends not merely on what there is to hear, but on our ears. Now, eyes and ears, and all the mechanism of perception, have, as we know, been evolved in us and our brute progenitors by the slow operation of natural selection. And what is true of sense-perception is of course also true of the intellectual powers which enable us to erect upon the frail and narrow platform which sense-perception provides, the proud fabric of the sciences.

Now natural selection only works through utility. It encourages aptitudes useful to their possessor or his species in the struggle for existence, and, for a similar reason, it is apt to discourage useless aptitudes, however interesting they may be from other points of view, because, being useless, they are probably burdensome.

But it is certain that our powers of sense-perception and of calculation were fully developed ages before they were effectively employed in searching out the secrets of physical reality—for our discoveries in this field are the triumphs but of yesterday. The blind forces of natural selection, which so admirably simulate design when they are providing for a present need, possess no power of prevision, and could never, except by accident, have endowed mankind, while in the making, with a physiological or mental outfit adapted to the higher physical investigations. So far as natural science can tell us, every quality of sense or intellect which does not help us to fight, to eat, and to bring up children, is but a by-product of the qualities which do. Our organs of sense-perception were not given us for purposes of research; nor was it to aid us in meting out the heavens or dividing the atom that our powers of calculation and analysis were evolved from the rudimentary instincts of the animal.

It is presumably due to these circumstances that the beliefs of all mankind about the material surroundings in which it dwells are not only imperfect but fundamentally wrong. It may seem singular that down to, say, five years ago, our race has, without exception, lived and died in a world of illusions; and that its illusions, or those with which we are here alone concerned, have not been about things remote or abstract, things transcendental or divine, but about what men see and handle, about those "plain matters of fact" among which common sense daily moves with its most confident step and most self-satisfied smile. Presumably, however, this is either because too direct a vision of physical reality was a hindrance, not a help, in the struggle for existence; because falsehood was more useful than truth; or else because with so imperfect a material as living tissue no better results could be attained. But, if this conclusion be accepted, its consequences extend to other organs of knowledge besides those of perception. Not merely the senses, but the intellect, must be judged by it; and it is hard to see why evolution, which has so lamentably failed to produce trustworthy instruments for obtaining the raw material of experience, should be credited with a larger measure of success in its provision of the physiological arrangements which condition reason in its endeavors to turn experience to account.

Considerations like these, unless I have compressed them beyond the limits of intelligibility, do undoubtedly suggest a certain inevitable incoherence in any general scheme of thought which is built out of materials provided by natural science alone. Extend the boundaries of knowledge as you may; draw how you will the picture of the universe; reduce its infinite variety to the modes of a single space-filling ether, retrace its history to the birth of existing atoms; show how under the pressure of gravitation they became concentrated into nebulæ, into suns, and all the host of heaven; how, at least in one small planet, they combined to form organic compounds; how organic compounds became living things; how living things, developing along many different lines, gave birth at last to one superior race; how from this race arose, after many ages, a learned handful, who looked round on the world which thus blindly brought them into being, and judged it, and knew it for what it was: perform, I say, all this, and, though you may indeed have attained to science, in nowise will you have attained to a self-sufficing system of beliefs. One thing at least will remain, of which this long-drawn sequence of causes and effects gives no satisfying explanation; and that is knowledge itself. Natural science must ever regard knowledge as the product of irrational conditions, for in the last resort it knows no others. It must always regard knowledge as rational, or else science itself disappears. In addition, therefore, to the difficulty of extracting from experience beliefs which experience contradicts, we are confronted with the difficulty of harmonizing the pedigree of our beliefs with their title to authority. The more successful we are in explaining their origin, the more doubt we cast on their validity. The more imposing seems the scheme of what we know, the more difficult it is to discover by what ultimate criteria we claim to know it.

Here, however, we touch the frontier beyond which physical science possesses no jurisdiction. If the obscure and difficult region which lies beyond is to be surveyed and made accessible, philosophy, not science, must undertake the task. It is no business of this society. We meet here to promote the cause of knowledge in one of its great divisions; we shall not help it by confusing the limits which usefully separate one division from another. It may perhaps be thought that I have disregarded my own precept—that I have wilfully overstepped the ample bounds within which the searchers into Nature carry on their labors. If it be so, I can only beg your forgiveness. My first desire has been to arouse in those who, like myself, are no specialists in physics, the same absorbing interest which I feel in what is surely the most far-reaching speculation about the physical universe which has ever claimed our experimental support; and if in so doing I have been tempted to hint my own personal opinion that as natural science grows it leans more, not less, upon an idealistic interpretation of the universe, even those who least agree may perhaps be prepared to pardon.

THE NATURE OF THE α RAYS EMITTED BY RADIO-ACTIVE SUBSTANCES.*

THE α rays emitted by radium and other radio-active substances have been shown by Rutherford ("Radio-activity," pp. 115-141) to consist of positively charged particles for which $e/m = 6 \times 10^3$. They are rapidly absorbed by gases and solids, the absorption coefficient being approximately proportional to the density of the absorbing medium. The value of the absorption coefficient in air, divided by the density, varies between 350 and 1,300 for different types of α rays. The velocity of these rays is 1-10 to 1-20 that of light.

It is interesting to compare the properties of these rays with those of cathode rays moving with about the same velocity; e/m for such rays is about 10^7, and the value of their absorption coefficient in air at 1 millimeter pressure is 0.85 (Lenard, Ann. der Phys., Bd. 12, p. 714, 1903) when the velocity is 1-10 that of light and 3.9 when it is 1-20.

The absorption coefficient for these rays is also proportional approximately to the density of the absorbing medium. Dividing 0.85 by the density of air at 1 millimeter pressure we get 540,000, and in the same way 3.9 gives 2,500,000. The corresponding numbers for the α rays are about 350 and 1,300. Thus we see that the α rays are nearly 2,000 times as penetrating as cathode rays moving with the same velocity.

Assuming that $-e$ for the cathode rays is equal to e for the α rays, we have for the ratio of their masses $10^7/6 \times 10^3 = 1{,}700$. It thus appears that the penetrating power of the α rays is to that of cathode rays, moving with the same velocity, approximately, as the mass of the α rays is to the mass of cathode rays. We may conclude from this that an α particle loses as much energy in colliding with an atom as a cathode-ray particle or corpuscle. If we regard the α particles as being of atomic dimensions (that is, as having a radius about 10^{-8} centimeters), while an electron or corpuscle only has a radius of about 10^{-13} centimeters, it is very difficult to understand this result. On the view that all atoms are assemblies of electrons, the fact that the absorption of cathode rays depends only on the density of the absorbing medium is regarded as indicating that the electrons penetrate the atoms and are absorbed by colliding with the electrons which compose the atoms. Since α particles lose the same amount of energy as electrons in penetrating matter, it seems probable that they also penerate the atoms and lose energy by colliding with the electrons in exactly the same way. If this view is taken, it becomes difficult to regard an α particle as of atomic dimensions, and we may look upon it as a positive electron exactly similar in character to an ordinary negative electron. The mass (m) of an electron is now regarded as being purely electromagnetic in character, and is given by the formula $m = 2e^2/3a$, where a is its radius and e its charge. For a negative electron this gives $a = 10^{-13}$ centimeters. Regarding an α particle as a positive electron, we get in the same way for its radius about $\frac{1}{2} \times 10^{-16}$ centimeters. On this view, therefore, the α particles are enormously smaller than the negative electrons.

The properties and modes of occurrence of the α particles are in agreement with the view that they are really positive electrons. For example, they are produced like cathode rays in electric discharges at low pressures (being then known as Canalstrahlen), and have very similar properties to cathode rays. The writer therefore suggests the view that α particles may be positive electrons having a radius about 2,000 times smaller than negative electrons.—Harold A. Wilson, Trinity College, Cambridge.

STATIONARY WAVES WITH N-RAYS AND SOME REMARKABLE CONCLUSIONS RELATIVE TO NERVE-WAVES.

M. AUG. CHARPENTIER has made a series of experiments in which he forms stationary waves with the N-rays in space. He measures the length of these waves, and finds that the eye and other parts of the body are capable of sending off special forms of rays into space, whose wave-length has a determined value. Thus the eye gives off two kinds of waves, and one set can be made to form stationary waves when reflected from a screen.

The observer places his body in position before a large reflecting screen. He holds a small copper plate in his hand, which is connected by a wire to a phosphorescent sulphide screen. The copper plate is moved back and forth in order to explore the region lying between the observer's body and the screen. Under these conditions the phosphorescent screen is seen to increase and decrease in brightness regularly, giving a series of maxima and minima of equally-spaced intensity. This seems to show that the N-rays which proceed from the observer's body form a series of stationary waves in the intervening space. M. Charpentier then measured the length of these waves, and found it to be about 3.5 centimeters (1.4 inches). Lead or wet paper do not stop the waves. Continuing the experiments, he uses a sulphide screen directly to explore the region, which gives better results, although the observation becomes more difficult. He starts from the region of the abdomen, etc. (instead of the heart, as before), and as a reflecting surface he takes a large marble plate which had been kept in the dark for a long time, and had thus lost the property of emitting N-rays. This latter precaution is essential. He finds a series of stationary waves, and could count as many as 14 maxima. The distance of the body from the reflecting screen was 52 centimeters (21 inches). The maximum points of intensity are well defined, as they

* Nature.

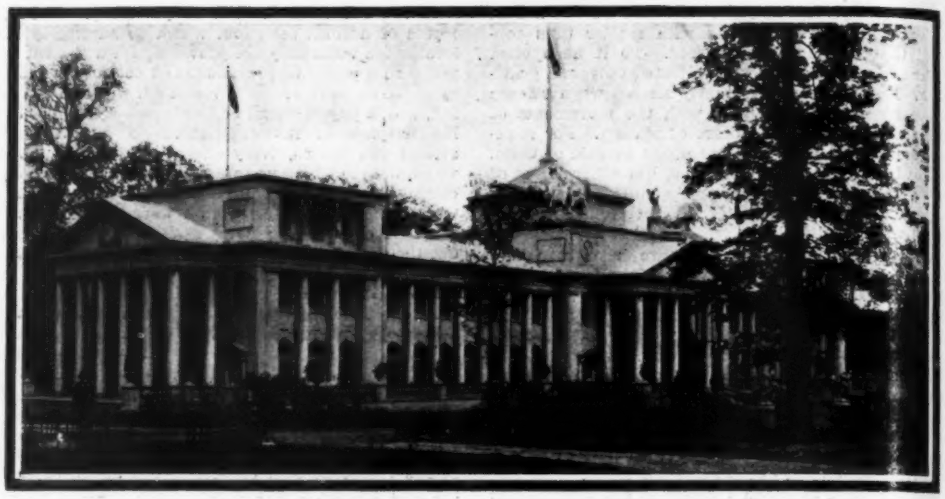
have a limited situation in space. When the sulphide is brought into that region it increases suddenly in brightness. It is remarkable that the interval between the maxima is exactly equal in mean length to the length of the nerve-waves which were found some time ago by M. Charpentier, and measured by a different method. He did not undertake to account for this coincidence, as this would be somewhat difficult in the present state of the researches. But this led him to make another experiment of great interest. He wished to find whether the same phenomenon is produced in the case of other nerve-waves. At present two of these have been observed and measured more or less closely. The retinian nerve system gives off two sets of waves. One of these has a wave-length of only 0.05 millimeter (0.002 inch), which is too short to be used here. But the other set measures 2 millimeters (0.08 inch), and these can be detected by an exploring screen in the air. To try this, he places the eye in front of a reflecting surface. The observer's face is held against a support to keep it steady. Upon shifting a phosphorescent screen in the space between the eye and the plane surface, the screen is seen to glow more or less at different points, and passes by a regular series of maxima and minima. These intervals can be easily measured and passed through five maximum positions. With several subjects and different observers, the mean wave-length was found to be 2 millimeters. Thus between the stationary waves in air and the retinian series, which was already measured, he finds as remarkable a coincidence as that of the nerve oscillations previously mentioned. While it is true that metals and other inorganic bodies will also give off the waves, this does not lessen the special interest of these experiments, as they show that the waves which are produced by different special portions of the human organism are transmitted to the outside and by the common medium.

NEW YORK STATE AT THE LOUISIANA PURCHASE EXPOSITION.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

NEW YORK STATE'S participation in the Louisiana Purchase Exposition is calculated to fully exploit the wonderful resources of the State as well as to set forth what the Empire State is accomplishing in the various lines of humanitarian work. The New York State Commission started out with the idea of making exhibits only in such lines where New York was pre-eminently the leader. On this account and for the reason that the appropriation was relatively limited, exhibits were planned to cover seven distinct departments. The most conspicuous feature of New York's participation in the exposition, especially so far as the impression upon the visitor is concerned, is her State building. An excellent site was chosen for this structure, and an able architect was engaged to draw the plans and specifications, and a handsome building was erected in a conspicuous place on the Plateau of States on the exposition grounds. While two other States, Missouri and Pennsylvania, have larger structures, upon which a greater outlay of money of course has been made, it is universally conceded that for beauty of architecture and splendor and appropriateness of appointments New York surpasses all of the other States. In fact, the New York State building is the admiration of all who visit it.

The building is simple, but extremely dignified in design, and of Italian architecture in the colonial treatment, and its extreme completeness, every detail having been carefully studied, makes it one of the most artistic and refined structures on the exposition grounds. One enters a very large hall running through to the dome, the lower part of which is treated in the Doric order, and the whole is scholarly, dignified, and beautiful in design. Another interesting feature in the hall is the organ case, which was designed particularly for this place. This hall is flanked on the



THE NEW YORK STATE BUILDING AT THE ST. LOUIS EXPOSITION.

northern side by a large assembly hall with a barrel ceiling running up to the second story, and the treatment of this room in old gold, Antwerp blues, and siennas is very beautiful. The draperies are in green velvet, and the chairs are of leather treated to represent the old Spanish illuminated leather. The floors are carefully made. There are rooms for banquets or functions of any kind. On the westerly side are the waiting rooms for men and women, writing rooms, and also retiring rooms and toilets. The waiting rooms are treated in the same simple, charming manner as the rest of the building, green being the prevailing color. Two handsome fireplaces flank the end, and one passes into a charming rotunda which is distinctively colonial in character.

The mural decorations of the large hall are worthy of the greatest praise. They have been done by Florian Peixotto, and represent DeSoto discovering the Mississippi, one showing the French and Indian occupation of the land, and others showing New York in 1803 and New York in 1903. The pendentives which support the dome have four emblematic pictures representing the four States most benefited by this purchase, the blue Mississippi in the background of each. The second story is divided into apartments for the commissioners and the offices of the secretary.

Education.—This exhibit is composite in nature, and has been subdivided under eleven heads.

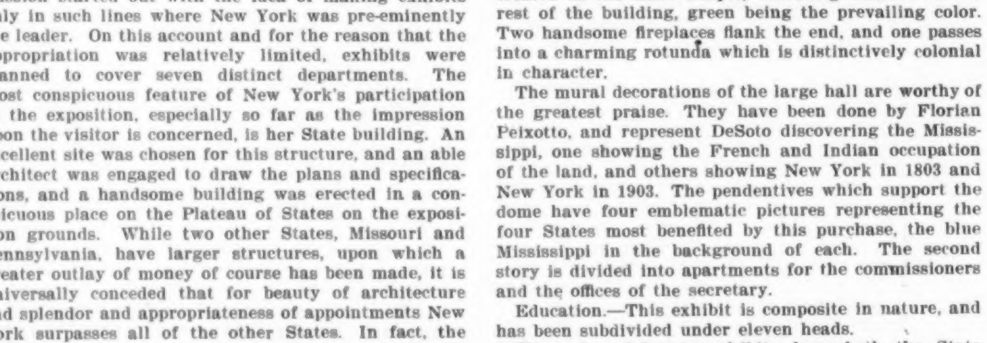
There are elaborate exhibits from both the State Department of Public Instruction and the University of the State of New York. In the public school exhibit contributions have been received from twenty-four cities and various villages. There is also a comprehensive exhibit from the rural schools of the State. In the normal school exhibit contributions have been received from every normal school, each school exhibiting in the part of the curriculum assigned it by a committee of normal school principals, appointed to prepare the exhibit. The training schools and classes of the State are very generally represented. Among the features of the exhibit may be mentioned a handsome collection of pottery from the New York State School of Clay Working and Ceramics at Alfred University; an exhibit of home-made apparatus containing contributions from various institutions; model of the New York State Normal and Training School at Fredonia, constructed by the students in the school; doll house constructed and furnished by the children of the practice school of the State Normal School at New Paltz; a series of charts bearing upon the educational activities of the State, prepared by the New York State Teachers' Association; a huge educational map of the State, locating and showing the grade of each institution of learning within the State; a handsome exhibit of art work from the New York School of Applied Design for Women, New York city. A complete catalogue of the exhibit is in course of preparation.

Social Economy.—Owing to the plan of installation adopted by the exposition authorities, the State exhibit in the Department of Social Economy will be found in several different places. The State Commission in Lunacy makes an interesting exhibit in which are shown the ancient and modern methods of caring for insane patients. A room containing the whirling chair and the peep door, shackles, etc., shows the torture to which they were formerly subjected, whereas a light, airy, pleasant room, containing modern furniture and appliances of every description, is in marked contrast, and shows the present method. This is supplemented by a complete exhibit of photographs of the various institutions, both exteriors and interiors, also a model showing the tent system for the treatment of tuberculosis. The State Board of Charities makes a very complete exhibit of the several State institutions under its jurisdiction. The State Labor Bureau sends a series of twenty-eight graphic charts bearing on labor conditions in the State, and gives valuable comparisons between New York and other States and countries. The State Department of Health furnishes an exhibit of the blanks generally used in the administration of the Department of Health, and graphically shows the work under their jurisdiction. The State Excise Department furnishes a series of graphic charts upon the receipt and disbursement of the excise moneys of the State.

Art Department.—From the following table, which shows the total number of exhibits by United States artists from all sources, including the works of artists temporarily residing abroad, and those representing artists of the State of New York, it will be seen that New York State has very nearly one-third of the total domestic exhibit:

	Total.	New York.
Oil paintings	903	389
Mural paintings	112	98
Water colors and pastels	313	167
Miniatures	89	42
Illustrations	177	121
Etchings, engravings, lithographs	267	195
Wood engravings	70	69
Sculpture	359	135
Architecture	289	63
Applied arts	945	133
	3,524	1,112

Agriculture.—The New York agricultural exhibit differs from the other exhibits in the Agricultural Building in that the object sought is educational rather than spectacular. New York has a greater number of varieties and sample exhibits than any other State in the building. In wheat there are over 500 varieties and about 1,000 samples. In corn New York has about 100 varieties and 300 samples. There are large exhibits of tobacco, salt, canned fruits of every variety, canned



MAIN ASSEMBLY HALL IN THE NEW YORK STATE BUILDING.

meats and fish, hops, flour, maple syrup and sugar, and vegetables. There are on exhibition and in cold storage over 300 varieties of potatoes.

Exhibit of Horticulture Department.—On the opening day of the fair, April 30, New York's exhibit of fruit was complete in almost every particular. The exhibit consisted of 30 varieties of apples, 10 of pears, and 3 of grapes. The fine collection of pears, consisting of 400 plates of 14 varieties, is attracting the attention and admiration of visitors and exhibitors from other States. They were taken from cold storage in almost perfect condition.

Forest, Fish, and Game Exhibit.—In exhibiting the timber indigenous to the State, two specimens of each species are shown in paneled frame work, showing both sides of the specimens. Only such species are represented in this manner as grow to a size permitting the cutting of boards 5 inches wide. One piece of each species is highly varnished on one side, and planed, but not polished, on the other side. The other specimen of each species is shown rough, directly from the saw, on one side; the other side is hand-planed. In connection with the specimens of timber are exhibited a series of photographs of trees of New York, 80 in number. Each tree is shown in leaf, and also as it appears in winter.

Sections of trees indicating the limit of growth of some important species are shown, and in connection therewith are exhibited sections of some spruce and pine trees of merchantable size, to show the number of years required to grow a forest available for timber.

A collection of all the insects injurious to the trees of New York, prepared by the State entomologist, is shown in an attractive manner in cases of special construction and pleasing design. The outside exhibit of New York consists of a nursery and plantation of forest trees. Here is shown how tree seeds are planted, germinated, and protected; and many species of both conifers and hardwoods of various ages, up to the size for transplantation, are displayed. As a part of the inside exhibit, in cabinets of special design, are shown specimens of substantially all the food and game fishes of New York. In preparing this exhibit of fish no attempt is made to show abnormally large specimens; but the purpose is to show the interested visitor the average fish, true to color and size.

A part of the inside exhibit is a typical hunters' camp under the name of "Camp Adirondack." It is constructed of spruce logs and roofed with spruce bark from the Adirondack forest by Adirondack guides, who are also builders. The furnishings are of the most approved design for summer life in the forest. The "camp" was first erected in the Adirondacks during the winter, then taken down and shipped to the fair. Hunting and fishing implements of approved pattern are shown, and grouped at the side of the "camp" are exhibited trophies of the chase in the form of a winter forest scene, which includes all of the animals, game birds, and other feathered life of the Adirondacks in winter. In front of the place is a tree carrying specimens of the perching and song birds of New York in the spring season.

In front of the "camp," in cabinets, are displayed specimens of all the game birds of the State.

ROYAL SLEEPING CARS IN 1842 AND 1904.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

IN the excellent exhibit shown by the London & Northwestern Railway Company in the Transportation Building at St. Louis were two sleeping cars, one a full-sized exhibit which had seen practical and distinguished service over sixty years ago, and the other a large model, one-fourth actual size, of a saloon car recently built for King Edward VII. The full-sized car is an historical relic of no small value, chiefly for the reason that it is the first recorded instance of the construction of a railroad sleeping car, antedating by two decades the first Pullman car built in this country. It was constructed for Queen Adelaide, the consort of William IV. of England, in the year 1842, at a private shop in London and it was used regularly by the Queen for running down from London to Leamington, where there was at that time a royal palace. The car was built for the standard gage, 4 feet 9 inches; it is 17 feet long over the frames, and 6 feet 4 inches wide. Inside it has a width of 6 feet 1 inch, and a clear height from floor to ceiling of 5 feet 9 inches, so that a tall man could not have stood erect in it. It consisted of three sections; first, a compartment with a single seat facing forward, and with glass running entirely around three sides of it, thus forming what in modern times we would call an observation car. The second compartment accommodated four people on seats that ran across the car and faced each other. The third and last compartment, and certainly the most interesting one, was the sleeping section. In the daytime it formed a four-seated compartment similar to the second section; but at night, by sliding forward an extension frame between the two seats and lifting up a flap that covered the "boot" (which is the name that was given to the extension which will be noted projecting from the rear of the coach) it was possible to make up a six-foot bed.

THE FIRST SLEEPING CAR EVER BUILT. QUEEN ADELAIDE'S COACH.

Just here it may be mentioned that this particular sleeping car, with its "boot" at the rear, was simply a development of the old private coach of the early half of the nineteenth century, which was arranged to be made up for sleeping purposes on the long journeys which were taken by members of Parliament and others who had to make rapid journeys between such distant places as London and Scotland.

The fact that the Queen did not hesitate to make free use of the new system of transportation, and that she had such confidence in it as to travel by night and in bed, acted as a great stimulus to railroad travel, which up to that time had been looked at rather askance by the wealthier classes, and it was considered that much of the sudden rise in popularity of railroad travel about the year 1845 was due to the example of the Queen. There is no doubt that the car herewith shown can lay claim to being the first sleeping car ever built and put in service.

The model of King Edward's saloon car is a fine sample of the model-maker's art. It is 17 feet in length and of proportionate height and width. The car itself is 65 feet long over the body and 68 feet over all. Its outside width is 9 feet, and its height is 13 feet 4 inches from rail to the top of the ventilator. The weight of the car is 45 tons. It consists of a bedroom, dressing-room, bath, library, a smoking-room, and an end compartment for the attendant, containing a couch and the general furnishings of a butler's pantry. The car is lighted by electricity generated from the axle. The model is complete to the very smallest details, the inside furniture in the way of chairs, tables, etc., being all made to scale of the same woods as those in the actual car. The total cost of the model was a little over $9,500.

MODEL OF 10,000-HORSE-POWER ALTERNATING CURRENT GENERATOR AT THE ST. LOUIS FAIR.

THE installation of the 5,000-horse-power dynamos at the Niagara Falls Power Plant, some years ago, was attended with much preliminary discussion, and it was watched with a corresponding amount of interest both by the professional and lay public. We have become so used to big things in the electrical line of late, that the fact that dynamos of exactly double the horse-power of the above mentioned are now

MODEL OF THE 10,000-HORSE-POWER DYNAMOS NOW UNDER CONSTRUCTION FOR THE CANADIAN NIAGARA FALLS POWER COMPANY. EXHIBITED IN THE ELECTRICITY BUILDING, ST. LOUIS

being built for the Canadian Niagara Falls Power Company, has attracted but little attention outside of the electrical world.

By far the most conspicuous object in the excellent exhibit made by the General Electric Co. in the Electricity Building at the World's Fair, is a model of one of these dynamos. It is built exactly to full size and gives an impressive idea of the vast proportions of the machine. It is so large that the base upon which it stands is high enough to provide a reception room for guests, the walls of which are covered with framed illustrations suitable to time and place. It will be remembered that in the dynamos on the American side of the Falls the armature was placed centrally and was stationary, while the field, which was of what is known as the umbrella type, was in the form of a covered cylinder, and revolved on the outside of the armature. In these larger dynamos the armature is on the outside and is stationary, the field revolving within it on a central shaft. The generator, which is of the alternating current type, has twelve poles and revolves at 250 revolutions, the current being generated at a pressure of 12,000 volts. It can readily be understood that the dimensions of the various parts of this machine are very large. Thus, the shaft has a general diameter of 14 inches and is enlarged to 16 inches at the hub. The revolving field is 12 feet 4½ inches in diameter, and the armature has an external diameter of 17 feet and a total depth of 10 feet 3 inches. It weighs about 115,000 pounds. The general arrangement of the intake canal, penstocks, wheel pit, turbines and tailrace, will be similar to that of the Niagara Falls Power Plant. The penstocks will each have a diameter of 10 feet and the depth to the bottom of the tailrace is 168 feet. The first installation of this plant consists of five of these machines; but the building is laid out for a total of eleven, making an aggregate normal capacity for the whole power station of 110,000 horse-power.

SALT.

By Prof. Charles W. Super.

Everybody knows the lines in Lucile in which the author declares that "civilized man cannot live without cooks." He also proposes the query whether there is any man in the world who can live without dining. The assertion is true only with important restrictions; for it will not be contended by anybody that every person who cooks is a cook, any more than it would be affirmed that every one who paints is a painter. The interrogatory may be frankly answered in the negative, since the great majority of mankind does not now dine and never has dined. They eat when they have food, and when they have none they do without. If we call this spasmodic way of supplying the interior department with materials for slow combustion, quadrupeds may be said to dine with as much propriety as *homo erectus*. If our poet had asked the question, Where is the man, civilized or uncivilized, who can live without salt? every one of his readers would probably have replied unhesitatingly, "He does not exist." It is doubtful, too, whether he ever existed. It is asserted by competent authorities that terrestrial as well as marine life is conditioned upon the consumption of salt. The position is hard to prove or disprove, as experiments that would give trustworthy results are almost impossible. It seems, however, fairly well established that man at the present day, no matter what his rank on the staircase of social progress, can not, or, at least, does not, live without this substance. What history has to say will be given below. That a historical record and an established fact are not interchangeable terms is, however, to be premised. Not only has this mineral been found in close proximity to almost every locality inhabited by man, or at least within his reach; it is sought with almost equal avidity by brutes. Most domestic animals are particularly fond of it. It is said to be fatal to some kinds of birds, though barn-yard fowls consume it without injury. The herbivora have an especial liking for it, whether in their wild state or domesticated. It is well known that the various salt licks in the United States were favorite places for ambuscades, and that both Indians and whites used them for the purpose of destroying the deer, buffalo and other animals that habitually resorted to them. Probably the most famous of these salt springs, or licks, as they are generally designated, is the Big Bone Lick, in Boone County, Kentucky. Prof. Shaler in his history of the State says:

"Not only do we find the bones of animals which occupied the country when the whites first came to it—the buffalo, the elk, the deer, etc.—but also deeper in the mire, or in portions that indicate a greater antiquity, great quantities of the bones of the fossil elephant, his lesser kinsman the mastodon, the musk-ox, an extinct long-legged buffalo, the caribou or American reindeer, and various other creatures which dwelt here in the time when the last glacial period covered the more northern regions with a mantle of ice."

The number of animals buried in the swampy soil about this lick is enormous. Many of them, in their eagerness to get at the brine, rushed beyond their depth, and before they were aware of it were borne down by their own weight until they were unable to extricate themselves, and so died of starvation. Others were probably pushed forward by those that crowded on from behind and trodden into the soft earth, where they died of suffocation. The locality was equally fatal to small and to large animals. How many years or cycles ago this destruction began we have no means of knowing, but that it continued to comparatively recent times is extremely probable.

Let us now examine some evidence which goes to show that man has lived without salt. Sallust in his "History of the Jugurthine War" says the Numidians live chiefly on milk and the flesh of wild animals, and that they use no salt or other relishes. Not only is the time to which the historian refers comparatively recent, but he has the reputation of carefully verifying his facts. His statements, therefore, carry great weight. It is held, moreover, that the Finnish name for salt is derived from an Indo-European root. If this view is correct the inference is natural and legitimate that the Finns did not know this commodity until they came in contact with Aryans, probably Slavs, from whom they got both the name and the thing, or rather the thing and the name by which they heard it called. In the Odyssey the renowned seer, Teiresias, directs Ulysses to travel until he comes to "men who know not the sea neither eat meat flavored with salt." Pliny supposes the Epirotes to be meant by this passage. But the point of chief interest is that to the Homeric Greeks a saltless people were supposed to live somewhere in the interior and in the most primitive condition. The poet, instead of naming a dozen points of difference, with epic prolixity, in life and usage between his own nation and this far-off tribe, has selected a single characteristic as sufficiently explicit for his purpose. Tacitus relates that toward the close of the first Christian century a great battle was fought between the Hermanduri and the Chatti for the possession of a river boundary, a salt-producing stream, because both parties believed that at this place heaven was especially near and that nowhere else could they address their prayers to the gods in such close proximity. There is reason to believe that this river was the Werra. On its banks, near the town of Salzungen, saline springs have been known from time immemorial and are still in use. The historian further relates that salt was produced near the river and in the contiguous forest, not, as elsewhere, by the evaporation of seawater, but by pouring brine over a pile of burning wood, with the result that the salt was precipitated as a consequence of the struggle between the two elements, fire and water. Evidently the sacred character that was supposed to attach to this saline substance was due to the belief held by the natives that salt was always a product of the sea, except by the special interposition of the gods, as in this case. That they had contracted a liking for salt elsewhere in their wanderings may be taken for granted.

Salt is now produced in many parts of Germany, but its existence in any form was not known at this remote period. The article produced in such a singular manner must have been very impure; but the palates of the primitive Germans were much less sensitive than those of their modern successors. At a later period the Alemani and the Burgundians are said to have frequently striven in battle for salt pits or saline springs claimed by both; but the region can not be definitely located. The record is chiefly interesting when taken in connection with the preceding and others of a similar character as showing the high value placed upon this substance by peoples that had hardly made a start along the highway of civilization. With respect to the above-mentioned method of making an impure grade of salt, it is worth noting that it is also spoken of as employed elsewhere. Varro had heard of a region where the inhabitants knew no salt, but used instead as seasoning a kind of salt coals which they obtained from burning wood. The same method and the same substitute for real salt are also reported as employed by some of the natives of Spain. Pliny devotes a good deal of space in his "Natural History," that storehouse of information and imagination, to the consideration of salt. He enumerates somewhat in detail the different places in almost the entire known world where it is found, describes the various methods of its production, notes the fondness of cattle for it, and adds that when mixed with their food it increases the quantity and improves the quality of the cheese. According to him, Ancus Martius, the fourth king of Rome, established the first salt works, and the Romans perform no sacred rites without *mola salsa*. By the Romans salt was regarded as almost the staff of life, and the salt-cellar was preserved in families because it was supposed to have a quasi-sacred character. In one of his Odes, Horace tells his friend, Grosphus, that the man who enjoys life is he whose father's salt-cellar gleams on his table. In a satire by the same poet, the rustic sage informs the epicure that bread with salt will appease his growling stomach, and advises him to spurn dainty viands. The cognomen Salinator, borne by a member of the Livian gens, came into prominence for two reasons. The first who received the appellation is said to have imposed a new impost on salt. He is further distinguished for the magnanimity he displayed in laying aside his private grudge against the other consul, Claudius Nero, for the good of the commonwealth. The hearty co-operation of the two commanders-in-chief and their armies led to the death of Hasdrubal and the complete destruction of his army. Wherever a system of taxation is framed with a view to raising the largest possible revenue, the heaviest burden falls on the necessaries of life. From almost time immemorial salt has had to bear a disproportionate share of this load. It is probable that in ancient times all regularly organized governments derived some revenue from this commodity. In Italy, as we have seen, the beginning was made long ago, though the details are lacking. In that country it is still a government monopoly. The profits realized are about 1,300 per cent, and its cost is almost prohibitive to the very poor. Such a delicacy do their children consider it that if they are allowed to choose between sweetmeats and salt they take the latter in preference. That a more liberal use of salt would improve the health and sanitary condition of this class hardly admits of a doubt.

It is safe to say that no article of consumption has been so ruthlessly exploited by governments to the detriment of their subjects as this one. Taking advantage of the fact that it is a necessary concomitant of the food of man and beast, they have made it an important source of revenue because its payment could not be evaded. In France, under the ancient régime, the tax on this article differed a good deal in the different provinces, but its transportation from one into another was prohibited. Its manufacture was also limited, and that which was produced by natural evaporation on the coasts was thrown back into the sea by the fiscal agents. While the price was enormous the great majority of the citizens were not allowed to buy as small a quantity as they chose; they were compelled to pay for a certain amount conditioned upon the size of the family. On the other hand, certain privileged persons received all the salt they wanted gratis; or, if they preferred, they had the prerogative of receiving money in lieu thereof. The king did not directly control the salt monopoly. He acted through an association of revenue farmers who paid into the fisc a fixed sum, after which they had the legal right to exploit their helpless victims to the utmost. They possessed police powers and used them unmercifully. Evasions of the salt laws were rigorously punished by the judges, who were almost always hand in glove with the salt-farmers. Every year for nearly two centuries there were from two to three thousand arrests. Those who were found guilty were subjected to fines, to the lash and to the galleys. In case of a second conviction they were sometimes hanged. The peasant was prohibited from using salt a second time. The brine from meat or fish had to be thrown away; it could not be used in the kitchen or taken to the stables for the cattle. It was illegal for any one to make salt from sea-water even for his own use, and equally illegal to water animals with natural brine. To prevent tanners and leather-dressers, who employed salt in their industries, from putting it to any other use the salt-farmers often poisoned it. Owing to the large number of different governments in Germany, and owing to some divergencies in matters of internal administration, one can not make a statement on this point that is applicable to the entire country. But in view of the strong inclination of many of the German monarchs to ape French customs, especially the bad ones, it is safe to say that the salt monopoly in the empire was quite as oppressive as in France. It may be added that on the whole the French peasant was not as badly treated as his German brother; the former first shook off much of the burden by drastic means from causes that need not be considered here. So late as 1840 a sort of salt conscription was enforced in Saxony which required each family to buy a certain quantity of it and prohibited its sale to a second party. In Prussia a similar regulation was abolished in 1816. Salt was a government monopoly in the greater part of Germany until 1867, as it still is in Austria, Italy and some other countries. In Austria all salt works belong to the government; such was also the case in some other south German states until recently. It likewise owns all salt-yielding territory. At present there is a general revenue law for the empire and a duty on the foreign product. It is therefore a good deal cheaper in the German than in the Austrian empire. While it is doubtful whether any article of consumption has so long afforded governments a means of oppressing their subjects as salt, and while its history makes an interesting though rather gruesome chapter in political economy, it is, nevertheless, unfair to judge the ruling powers of the past by contemporary standards. Until comparatively recent times economic laws were so little understood and rulers were always so hard pressed for money that they were constrained to resort to such measures for raising revenue as promised the largest and most certain returns. In the nature of the case a commodity in such demand as salt had to bear a disproportionate share of the public burdens. Cruel and inhuman methods of legal procedure were the order of the day, and those who suffered from it did not themselves know any better way of attaining the ends in view. It is greatly to the credit of the English people that their jury system did much to mitigate the penalties to which many a transgressor against the revenue laws as against other laws made himself liable. Though juries could not change the status, they refused to convict when the penalty seemed too great for the offense.

The United States has never collected revenue from salt, but when provision was made by Congress for the government of the Northwest Territory and for the sale of lands therein, it took care to reserve the salt licks, apparently fearing that they might be made a means of extortion to the consumers of this indispensable article of diet. One section of the act of Congress reads:

"That a salt spring lying upon a creek which empties into the Scioto River, on the east side, together with as many contiguous sections as shall be equal to one township, and every other salt spring which may be discovered, together with the section of one mile square which includes it, also four sections at the center of every township, containing each one mile square, that shall be reserved for the future disposal of the United States; but there shall be no reservation except for salt springs, in fractional townships, where the fraction is less than three-fourths of a township."

We read of bloody battles between Germanic tribes

for the possession of salt springs, and the inference is perfectly fair that the rumor of very few has come down to us by means of the written and the printed page. In the new world rival Indian tribes in like manner often contended fiercely for the same flowing treasure. Here too we find a repetition of the nomenclature of primitive Europe. There are several salt rivers in the States formed out of the Northwest Territory, besides salt creeks, salt licks, and other names, due to the presence of natural salt. The number is doubtless very much larger than the list given in the ordinary gazetteers, as the insignificant ones are not mentioned.

Although there are few regions in any part of the world in which there are neither saline springs nor deposits of rock-salt, it is probable that the Aryan name was derived from the sea and that the first salt was obtained from it by natural evaporation. In Homer *als* means both salt and the sea; or perhaps it would be better to say that salt is named from the sea because the saline property of sea-water is its most salient characteristic. The designation *als* is more particularly applied to that part of the sea which is near the land, as also to its bays and inlets, those parts with which man in the nature of the case was most familiar. In the Roman territory there existed in ancient times a Via Salaria, or Salt Road, which extended from the territory of the Sabines to the mouth of the Tiber, along which these people were permitted to transport salt for domestic use from the Mediterranean through the Roman country. The early Italians were, therefore, also dependent on the sea for their salt. It is noteworthy that Homer does not mention salt as employed in connection with sacrificial ceremonies. On the other hand, Virgil speaks of it as in regular use among the Romans, as do also other writers. While it is always unsafe to base conclusions on the evidence of silence, another ancient author quoted by Athenæus says that in former times the Greeks burned the sacrificial parts of animals without salt, and that the custom continued into later times in conformity with the ancient practice. Here then we have Homer's silence supplemented by positive testimony. It is well known, moreover, that all peoples are more conservative in religious usages than in any other. The adhibition of salt, the *mola salsa* of the Romans, seems not to have been borrowed from the Greeks, as were so many of their religious ceremonies. Like the Romans with their salted meal, the Hebrews were careful not to omit salt from their sacrifices, though the former may not regularly have put it on the flesh of the slain victims. In Leviticus we read: "And every oblation of thy meal offering thou shalt season with salt, neither shalt thou suffer the salt of the covenant of thy God to be lacking from thy meal offering; with all thine oblations thou shalt offer salt." From this command it may be inferred that salt was a part of bloody sacrifices as well as of those of the fruits of the earth.

In Germany there are many place-names that contain the Keltic root *hal* which seem in some way to be connected with sodium chloride. The best known of these is the city of Halle on the river bearing the Teutonic appellation, Saale. It is not easy to see how this double designation originated and conjectures are feeble arguments. There is no doubt, however, that Halle got its name from the salt springs near it. In the same country there were anciently several rivers called Sala on the banks of which salt works bearing the name Hall were planted. Besides the Halle already mentioned there is Reichenhall in Bavaria, Hallein in Salzburg, Hall in Tyrol and in Swabia, as also Halen in Brabant, and others. In Czech there are likewise a number of words containing the radical *hal* that have some connection with salt. This root is still distinctly preserved in the Welsh "halen," salt. In some of the Keltic dialects, however, the initial h is represented by s.

In England there are a number of inland towns to the names of which the suffix wich, from the Norse vic, a bay, is appended. This seeming absurdity is easily understood when we remember that a wychhouse or wickhouse and a bayhouse came to be regarded as synonymous terms, and that wychhouses were erected where salt was prepared from brine, though they might be far from a bay. In the same way a coarse kind of salt came to be called baysalt from its similarity to the crude article of primitive manufacture. The wics in Essex were probably the first localities where salt works of the rude original type were erected. According to Isaac Taylor, the Domesday book gives the names of three hundred and eighty-five places in Sussex alone where salt was made. The number seems incredible and may be a misprint; but the general fact is well established.

In Great Britain, as on the Continent, salt was obtained before the advent of the Teutons or the Romans. Here, too, we find our guide in the syllable "hal," which occurs in place-names in Carnarvon, in Hampshire, in Lancaster, and elsewhere. Plutarch has left upon the record some evidence that points to a period when salt was practically unknown in Egypt. He says the priests will permit no salt upon their tables, will not address a pilot because of his occupation at sea, and that they also eschew fish for the same reason. Another passage seems to modify this strong statement to this extent that there are certain times when the priests do not partake of salt for the reason that it increases the desire for food and drink. All Greek evidence on such points is, however, of small value, since to the Greeks Egypt was at all times a wonderland where the most singular and unique customs prevailed. Long before Plutarch's time Herodotus reported to his countrymen that the people of the Nile valley did everything different from his own countrymen. A special ceremony or a custom observed only on particular occasions was easily perverted to a general usage by persons who had merely a superficial knowledge of the conditions.

Northern Africa has from time immemorial been a great storehouse of salt. Thebes in Egypt was the starting point for caravans that moved across it toward the west, perhaps as far as the Niger. Herodotus relates that a ten-day journey from the city heaps of the mineral lie in large lumps upon the hills and that from the tops of these hills salt water gushes forth. It is in this region that the Ammonians dwell, in whose district is the celebrated temple of Jupiter Ammon. The oasis is the bottom of what was once a salt lake or part of the sea and still has many salt springs in it. The soil is also impregnated with salt, although there is no scarcity of fresh water. It is probable that the chemical compound known as sal ammoniac gets its name from this region, either because it was first manufactured here or because it was found here in its natural state.

In many parts of northern Africa, often at long distances from the coast, salt occurs in great abundance. Though there is generally stone in plenty, the inhabitants in some places use blocks of salt for constructing dwellings, since it is easier handled and there is no danger to be apprehended from rain, which rarely falls in this part of the world. The salt blocks employed for this purpose are, however, not pure. They are cemented with mud, probably owing to a scarcity of lime. Some portions of the Sahara are covered with a crust of salt to such an extent as to give long reaches the appearance of being covered with a recent fall of snow. Some of the statements of Herodotus and other ancient writers are perhaps exaggerated, but many of them are corroborated by recent explorers. M. Dubois in his work "Timbuctoo the Mysterious," affirms that salt is as highly valued as ever in this part of the world, in spite of its great abundance. He found salt mines in the heart of the desert near a place called Thegazza. For the Soudanese, salt has from time immemorial represented, and still represents, the principal article of commerce and their most precious commodity. The long depression in the western Sahara bearing the name of El Djouf is a vast mine of rock salt. The salt mines of Thegazza were abandoned in the sixteenth century for those of Taoudemi, nearer Timbuctoo. The same explorer reports that even here the houses are built of rock salt and roofed with camel skins. Under a thin covering of sand the mineral is found in clearly marked layers. It is dug out in large lumps and trimmed down to blocks about three and a half feet long by one and one-fourth feet in breadth. It looks like bars of red or gray-veined marble, and as they come out of the mine they are stamped with the trade-mark of the different contractors. At Timbuctoo they are embellished with designs in black paint and the name of some venerated chief is written on them in Arabic characters. They are then bound round with thongs of raw leather so arranged as to hold the parts together in case of fracture. The densest and whitest blocks are most in demand, those veined with red being of an inferior quality. Timbuctoo is the entrepot of the whole region lying southeast as far as Lake Chad. There is nothing that the Soudanese possesses that he refuses to part with for a lump of salt. To these people it is more valuable than gold itself.

In ancient as well as in modern times the partaking of salt with another person was regarded as the symbol of friendship and hospitality. Among the Slavic peoples it is still the custom to welcome the stranger with a proffered gift of salt and bread; while in cases of dispute the Arab is wont to appeal to the bread and salt he has eaten with his adversary as proof of sincerity. The advice embodied in the injunction, "Before you make a friend, eat a bushel of salt with him," has been proverbial from the remotest times. Both Aristotle and Cicero refer to it as current in their time. An ancient commentator on Homer says that salt is regarded as the symbol of friendship, *par excellence*, either because it was offered to guests before anything else, or because salt more than any other substance is a prophylactic against decay. In Numbers certain offerings are enumerated as constituting "a covenant of salt for ever before the Lord unto thee and thy seed with thee." Perhaps the custom of handing down the salt vessel from generation to generation in Roman families has some connection with the idea of incorruption.

The word "salt" has impressed itself on our language in a curious way in our term "salary." So necessary did the Romans consider salt to the efficiency of their armies that each soldier was provided with a special ration of it, or with the means of providing it. This stipend was called *salarium argentum*. Civil officials or military officers when traveling in a civil capacity were also provided with this ration of salt. In later times, when the commodity was no longer difficult to obtain, money was paid in lieu of salt, but still ostensibly for the purpose of providing the same article. Generally, however, the allowance was sufficiently liberal to purchase a good many things besides sodium chloride. In time salt-money in ancient Rome came to be as comprehensive as "stationery" in the phraseology of our home-grown legislators. The officials received no salary, yet the unfortunate provincials would generally have been glad to pay a definite amount rather than the presents (?) and perquisites which they were called upon to provide. A salary usually means a fixed sum, but there never has been framed a clear definition of "necessary expenses."

As indicated above, it is still a mooted question whether the consumption of salt is essential to the maintenance of animal life. If, as is now generally held, marine fauna antedated all others, it is reasonable to suppose that the principle of atavism would never carry living beings beyond a natural fondness for and even the necessity of consuming saline matter. On the other hand, it is maintained by some competent authorities that a sufficient quantity is taken into the system by the herbivora to supply all natural requirements. From these it passes into the bodies of the carnivora. Those who insist that sufficient salt is taken into the animal body indirectly with the food are equally positive that the excessive fondness for it exhibited by most men and some other animals is the result of a perverted taste. They cite as a parallel case the eagerness with which dogs and other brutes, to say nothing of human beings, devour sweetmeats, as evidence of a vitiated taste that readily results in more or less serious harm. Certain it is that no mineral substance has ever been so eagerly sought as an ingredient of food and it is probable that the quantity consumed is on the increase. But whether animal life is possible under conditions where salt is wholly absent can, in the present state of our knowledge, be neither categorically affirmed nor positively denied.—Popular Science Monthly.

NITROGEN-GATHERING BACTERIA.*

By JOHN R. CAIN.

SINCE the earliest applications of chemistry to agriculture, man has been confronted with the nitrogen problem. Chemical analysis had not long been applied to agriculture until it was known with a fair degree of definiteness that certain inorganic elements must be present in the soil as a prerequisite to plant life. Among these elements nitrogen was found to be one of the most important, and the attention of scientific men was thus at a comparatively early period directed to the necessity of finding abundant supplies of nitrogen compounds capable of use as fertilizers, and to the necessity of conserving the nitrogen compounds already present in the soil. It could be seen that at no distant date the existing nitrogen supply would be depleted, for it was found that plants were unable to assimilate the nitrogen of certain compounds. In general, experience showed that the nitrogen of complex organic bodies, as well as elementary nitrogen, was incapable of assimilation by growing plants. So far as knowledge then was concerned, man's one source of nitrogenous fertilizers was found in the deposits of mineral nitrates which have been formed at various times and places, notably at Chili, by natural processes as yet but little understood. Evidently, these deposits were of limited extent and chemists and others were soon brought face to face with the question, After the nitrate deposits are exhausted, where shall the farmer obtain his nitrogen? It was recognized that this was a question of vital importance, for the cycles of nitrogen in nature are such that the nitrogen given to the soil as nitrate returns ultimately to the elemental state—that is, adds itself to the nitrogen of the air, so that as far as all agencies then known were concerned, nitrogen tended constantly to assume forms unavailable for life processes. Unless means could be devised to cheaply reconvert the atmospheric nitrogen into assimilable forms, it was evident to the scientific men of a few years ago that the world would soon be threatened with nitrogen starvation. It was this idea which stimulated the scientific thought of the day to attack what seemed a problem well-nigh incapable of solution, for the element nitrogen is an extremely inert substance which is most stable in the uncombined state, and all attempts to get it in a form available for plant food at a price at all reasonable, seemed futile. Perhaps the most practicable solution offered was that of Crookes, who proposed to convert the nitrogen of the air into nitric acid by the agency of the electric spark. This is a reaction which may be brought about fairly readily, and with cheap sources of current would perhaps prove practicable.

But in the meantime another solution of the vexing problem came to light, and from an entirely different quarter of the scientific world. Here, as is often the case, practical use had long been made of the agency before its scientific bearing or explanation were properly known; for many years' experience had taught farmers that a certain succession of crops gave the best results. Notably, certain crops following clover and other plants belonging to the *Leguminosæ* family were found to succeed unusually well. Naturally, on the advent of agricultural chemistry, an explanation was sought. Repeated analyses showed the benefits of this rotation to be directly traceable to the increased stores of nitrogen placed at the disposal of the benefited crops. Very evidently, then, plants of the *Leguminosæ* type were in some way able to render available nitrogen which would otherwise be unavailable. Further investigations showed that this nitrogen came neither from otherwise unavailable forms in the soil, nor from nitrogen compounds, such as ammonia, in the air. It could, then, only come from the nitrogen of the air, and the problem was to find by what agency this feat, so difficult to perform by purely chemical means, was accomplished. Was the nitrogen fixed during the life process of the plant, or was it fixed by outside sources, or by the two working in conjunction? The immediate agency of fixation was soon found, and to a consideration of this we now turn, leaving open, as it now is, the answer to the last

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

question as to the ultimate nature of the process. It is enough to say that our present knowledge of nitrogen assimilation is so satisfactory that the process is capable of direct scientific control and admits of definite prediction of effects from given causes—from a practical standpoint the best measure of its value.

The first step in investigating the action of *Leguminosæ* was the observation of the facts that such plants, in distinction from most others, have well-defined nodules on their roots, and that such nodules on analysis show high percentages of nitrogen. The next step was the all-important discovery that these nodules are the habitat of a lower form of life—a bacterium—which is the indispensable agent in all such processes of nitrogen assimilation. That such is the case has been demonstrated by innumerable experiments. Perhaps the most convincing are those of Hellriegel and Wilfarth (Tagl. d. 59 Versamm. deut. Natur. für Aerzte, Wiesbaden, 1887), pioneers in this field of research. They grew leguminous plants in sterilized sand, some being watered with sterilized water and other with water which had been in contact with the roots of *Leguminosæ* and was thus inoculated with the organisms; these plants had access to air carefully freed from organisms. They found that some plants flourished while others did not. On examination it was found that in every case the healthy plants had tubercles on their roots, the others either had none, or they were poorly developed. It was found in all cases that the rate of growth was proportional to the number of root tubercles present. One could hardly be led astray in arriving at conclusions from such positive results. It was clearly a question of bacterial life, for the plants were grown under such conditions of sterility in the one case, and access of the suspected organism in the second case that clearly this was the primary agency involved in the process of nitrogen fixation. To make the matter still more certain, Hellriegel tried the effect of sterilizing his soil, infusion, and found at once that it had lost its power of stimulating the growth of the plants which it was used to

of the plant may prove, in the light of future knowledge, to contain a grain of truth.

Prazmowski (Landw. Vers. Sta., 38, 1890) made further experiments along the lines laid down by Hellriegel, and the result was a complete confirmation of the latter's results. Prazmowski's experiments have always been held in high repute, because they were conducted with great experimental skill, and because of the great care he took to eliminate the disturbing influence of the presence of organisms from the air. Since these experiments, numerous others confirming them have been made.

The point being settled with a fair degree of certainty that the fixation of nitrogen in the case of *Leguminosæ* is directly traceable to a bacterium, the question began to be investigated more minutely, and information was desired about the life process of the bacterium—under what conditions as to food, light, heat, moisture, habitat, etc., it thrived; as to the exact manner in which the plant appropriated the nitrogen brought to it from the air, and the chemical form of this nitrogen; and finally as to the possibility of artificially stimulating or controlling the assimilation process, in connection with the various phases of agriculture. On some of these points our knowledge is fairly satisfactory, but on others there is yet room for much investigation.

The bacteria have been isolated and grown in pure culture by many investigators, and a great deal has been found out about them in this way. Among these investigators may be mentioned: Laurent (Ann. de l'Inst. Pasteur, 1891); F. Nobbe (Chem. Ztg., 20, 1896); Neumann (Landw. Vers. Sta., 56, 1901); Maria Dawson (Phil. Trans. Royal Soc., London, 1900, pp. 51-67); R. G. Smith (Centbl. Bakt. u. Par. 2, Abt. 6, 1900, No. 11); M. Gonnermann (Landw. Jahrb. 23, 1894). Also investigations contained in Proc. Indiana Acad. Science, 1900, pp. 157, 161, and Jour. Soc. Chem. Ind., 15, 1896.

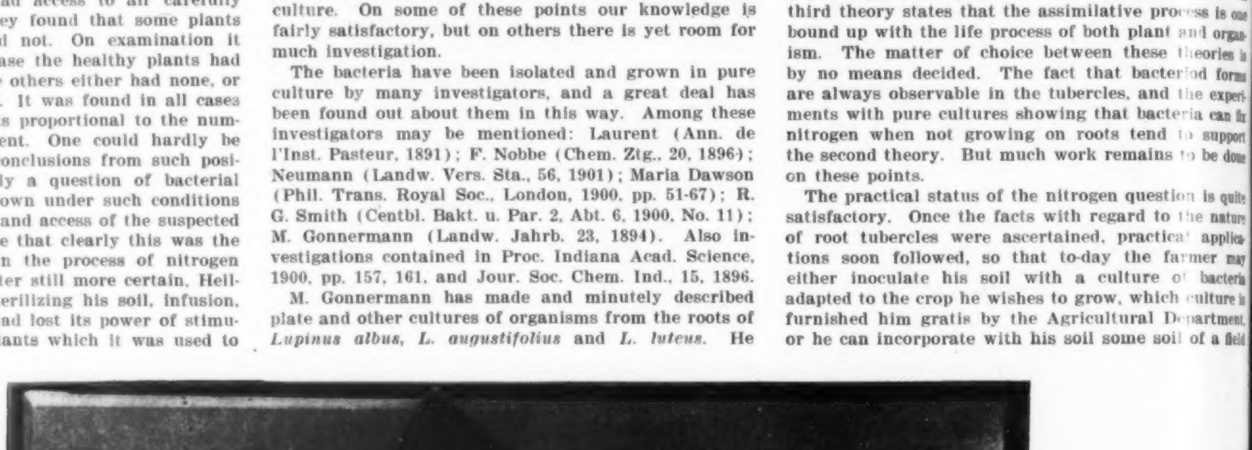
M. Gonnermann has made and minutely described plate and other cultures of organisms from the roots of *Lupinus albus*, *L. augustifolius* and *L. luteus*. He

present in moderate numbers a few inches below the surface. They are very sensitive to light and to conditions of acidity or alkalinity of soil, and thrive best in a moderately humid soil. Frank (Ber. Deut. bot. Ges., 271-8) found that the compounds stored up by the tubercle, when detached from the main plant for some time before analysis, show a different composition from that of nodules taken fresh from the main plant for analysis. In such cases free nitrogen was found to be given off in the case of the detached nodules.

From all this it will be seen that many facts about these organisms are known, many of which, although now only isolated observations, will one day contribute data for a complete theory of the nitrogen cycle in nature.

We must now briefly notice the theories which have been advanced as to the ultimate nature of the assimilation process. Some have claimed that the bacteria in their life processes produce enzymes which in one way or another fix the nitrogen in forms available for plant life. Another theory states that the bacteria during their life incorporate atmospheric nitrogen into their bodies, and that this becomes available for the plant when they pass into the bacteriod form. A third theory states that the assimilative process is one bound up with the life process of both plant and organism. The matter of choice between these theories is by no means decided. The fact that bacteriod forms are always observable in the tubercles, and the experiments with pure cultures showing that bacteria can fix nitrogen when not growing on roots tend to support the second theory. But much work remains to be done on these points.

The practical status of the nitrogen question is quite satisfactory. Once the facts with regard to the nature of root tubercles were ascertained, practical applications soon followed, so that to-day the farmer may either inoculate his soil with a culture of bacteria adapted to the crop he wishes to grow, which culture is furnished him gratis by the Agricultural Department, or he can incorporate with his soil some soil of a field



LUMINOUS DEEP-SEA FISH MODEL.

water. Hellriegel came to the conclusion that the bacteria in question are normally present in the soil, but that they do not produce the characteristic effect referred to until they have gained entrance into the roots of a plant and under favorable circumstances multiply in that environment. He found out the further important fact that each species of leguminous plant has a bacterium peculiar to itself and that the organism of plant A, for instance, could not do satisfactorily the work of the organism of plant B. By analogy, this relation of bacteria to plant life seems almost a parasitical one, and it led many scientists to doubt the validity of Hellriegel's conclusions. If the bacterium is only a parasite, so that its life if not indispensable to that of the plant, is it not possible that the plant could live as well or better without it? Frank (see Landw. Jahrb., 1890) is the stanchest supporter of this view, and his experiments led him to the conclusion that some plants, notably pease and clover, when grown in a rich soil containing plenty of available nitrogen, do not need the tubercles at all. But when the same plants are growing in a poor soil, low in nitrogen content, the tubercles seem to enter into the problem, stimulating the plant so as to enable it to secure its nitrogen from the air. He concluded that nitrogen assimilation does not take place directly through the bacterial agency, but that the presence of bacteria acts merely as a stimulus to the life power of the whole plant. He came to two other conclusions, namely, that different bacteria are not peculiar to different species of plants, and that the organism when grown in pure culture does not possess the power of fixing atmospheric nitrogen, which would, if true, quite invalidate the idea that the fixation process is dependent solely on the presence of bacteria. But subsequent investigations have proved beyond doubt that these latter conclusions were erroneous, and this fact, coupled with the further fact that Frank was not very careful about the sterility of the air admitted to his growing plants, cast doubt on his whole work; but it seems probable that his conclusions were not wholly wrong. His idea of the stimulation of the life process

found several forms of micrococcus and bacillus and claims to have found evidence to indicate that the organisms are spore-forming, thus explaining their ability to last through the cold of winter. In Proc. Ind. Acad. Sci., 1900, pp. 157-161, there are described cultures of organisms from the roots of *Trifoleum protense*, *Vicia sativa*, *Phaseolus nasus*, *Trifoleum hybridum* and *Trifoleum reflexum*. In confirmation of M. Gonnermann's results, many distinct forms of bacteria were found to be present. Some were aerobic and some anaerobic; all grew well on agar and gelatin; some liquefied the gelatin, others did not; some were motile, while others possessed but little power of motion. These bacteria grew well on most of the other media ordinarily employed in a bacteriological laboratory, such as potato, milk, saccharose bouillon, etc. The growth in bouillon, however, is not strong. Bacteroid forms were but rarely seen in pure cultures. Nobbe found that pure cultures retained their vitality and power of producing tubercles for as long as two months; after an interval of seven months the power was found to be lost. Maze incidentally made the interesting observation that some of these tubercle bacteria are pathogenic to certain animals. Smith (Centbl. Bakt. u. Par. 2 Abt. 6, 1900, No. 11) gives a method for staining the flagella of motile forms. Laurent showed (in contradiction to Frank's idea) that the bacteria fix nitrogen when grown in artificial media. Breal (Ann. Agron. 15, 1889) found that plants could be very readily inoculated by simply piercing a root and placing a small portion of a pure culture of the tubercle organism in the opening, or by inserting a piece of a nodule. Lawes and Gilbert (Abs. in Exp. Sta. Record, III.) state their belief that the organisms fix their nitrogen only in contact with the roots on which they produce tubercles, and were led to the conclusion that the bacteria themselves possess the power of fixing nitrogen. An interesting observation made by them was to the effect that the nodule invariably gives an alkaline reaction when freshly cut.

It has been found that the bacteria possess but little power of spontaneous diffusion in the soil, and are only

where the crop has already been successful, and which is therefore full of the beneficial organisms, and, other conditions being right, he can count on a good yield. Such inoculations have been practised with success all over the United States and Europe, so that, thanks to the combined labors of the scientist and the farmer, the danger of nitrogen starvation may be said to no longer exist.

LUMINOUS DEEP-SEA FISH.

THE United States government, through its National Museum, had intended to exhibit at the Pan-American Exposition a series of enlarged models of fishes of the deep sea. Our picture comes from a report of the United States National Museum. It proved impossible, however, to construct these in the time available, but a single example was prepared. The species chosen was one known as *Aethoprora effulgens*, belonging to a characteristic family of deep-sea fishes, many of which are remarkable for their phosphorescent organs. In the species exhibited there is in addition the luminous spots on the sides found in many deep-sea fishes, a large luminous area like a lantern on the top of the head. This extraordinary creature must present a remarkable appearance when swimming in the dark abysses of the ocean. The model shown at Buffalo was eight times natural size and had a length of feet. The luminous spots on the sides were represented by buttons of glass connected with the interior by tubes. The luminous protuberance on the head was modeled in gelatine and tinted. The model was connected with the electric-lighting system in the building that a gentle glow appeared in the side spots and frontal protuberance, producing a very striking and it is believed a quite accurate notion of the appearance of a living phosphorescent deep-sea fish.

Composition of an Internal Disinfectant.—In the application of the better known disinfectants, such as formaline, carbolic acid, formic acid, lactic acid, acetic acid, and others for the disinfection of the internal organs of the human body it is not unusual to note the

appearance of harmful intensely irritating effects as secondary symptoms and following closely upon them the symptoms of cellular poisoning. When the following disinfectant is used the secondary poisoning effects are said to be avoided. This highly-to-be-desired end is attained by adding to the chief ingredient, formaldehyde, materials found in the healthy cell where its natural function is to protect the tissue against the attack of bacteria. This material is cell-core acids which is applied in small quantities, either in alcoholic or chloroform alcoholic solution, or paired with other organic acids, such as formic acid, for instance. Through its application a startlingly powerful disinfecting effect is produced. This remedy is peculiarly adapted to the disinfection of the pulmonary organs by inhalation.—Dr. K. Spengler's Patent.

IS THERE SNOW ON THE MOON? A STUDY OF THE LUNAR APENNINES.

By E. Walter Maunder, F.R.A.S.

The principal object in the accompanying plate, which is reproduced from one of the superb photographs taken by MM. Loewy and Puiseux, with the great equatorial *coudé* of the Paris Observatory, is the range of the lunar Apennines, by far the grandest mountain chain upon the moon, and the one which, at first sight at least, most strongly resembles those of our own earth. It is shown in its entire length of more than 400 miles from the fine ring-plain Eratosthenes, in the extreme right-hand upper corner of the plate, which forms the termination of the range to the south, down to the grand promontory of Mount Hadley, more than 15,000 feet in height, in which it ends toward the north. About half way between the two extremities of the range is the magnificent headland of Mount Huyghens, according to Schröter nearly 21,000 feet in height, the highest summit on the moon with the exception of some of the peaks on the ramparts of the ring-plains of the south polar cap. A third great promontory, Mount Bradley, lies nearly midway between Mount Huyghens and Mount Hadley, and reaches a height of about 16,000 feet.

The highland region, of which the Apennines form the northeastern face, is roughly triangular in shape. By far the loftiest and steepest face is that overlooking the great Mare Imbrium toward the east. The northwestern face looks over the Mare Serenitatis, while the Sinus Æstuum and the Mare Vaporum bound the region on the south.

The area of the plate is not one which includes many of the circular formations so typical of the moon, but some of those which are shown are very striking. Three great ring-plains are seen on the floor of the Mare Imbrium. These, in order of size, are Archimedes, the largest and most eastern; Aristilles, the most northern; and Autolycus, the smallest of the three, just opposite the broad gap which separates the Apennines from the Caucasus. On the opposite side of this opening, and slightly further from it, the celebrated crater Linné is seen as a small white spot on the floor of the Mare Serenitatis. Toward the extreme upper left-hand corner of the plate, near the border of the same Mare, stands the bright crater Sulpicius Gallus, and among the actual highlands of the Apennines are the two craters Conon, just behind Mount Bradley, and Aratus, a little farther north toward Mount Hadley. These seven are the most notable circular formations in the plate. In general, the lunar mountains take the form of rings or polygons, as in the case of these seven objects, and do not make continuous chains as on the earth. To this rule the Apennines constitute the most conspicuous exception, but a detailed examination of them shows that the differences between them and the great terrestrial ranges are numerous and significant.

The first feature of the Apennine highlands to claim attention is the nearly triangular form of the area they cover. This is a necessary consequence of the roughly circular form of the great Maria which border them. Wherever we have a number of circular depressions contiguous to each other, the more elevated interstices must necessarily approximate to triangles. And this being the case, it follows that the forms of the highlands have been determined by the Maria and not the reverse. In other words, the highlands existed first and acquired their present outlines through the later formation of the surrounding Maria.

The next feature to be noticed is the general slope of the region. Toward the Mare Imbrium, on the east, the face presented by the Apennines is exceedingly bold and steep; toward the Mare Serenitatis and Mare Vaporum on the west and south the highlands sink down gradually.

The result of such a formation upon the earth would be obvious. There would be a deposition of moisture over the whole highland region, either in the form of snow or water, and this moisture would move downward toward the plains either as streams or glaciers. But it would move with very different speed and different effects upon the two faces. On the steep escarpment facing east neither water, snow, nor ice could rest. The moisture would be quickly thrown off, descending in waterfalls or avalanches down to the plains, and wearing away the cliff face into a great number of narrow gorges or gullies. The *debris* would be deposited at the foot of the cliffs, and the torrents would carve their way some distance into the plain, as a rule in a direction at right angles to the range, smoothing out and covering all irregularities which ran parallel thereto. What we actually see upon the photograph is as unlike this as could well be imagined. The base of the range in the Mare Imbrium is confronted by a line of low hills—wrinkles, as it were, on the surface of the plain—suggesting by their parallelism to the range that no effective amount of moisture, either as rain or snow, had been deposited on the eastern slopes of the Apennines since the Mare Imbrium was formed.

But the main drainage of the region would be in the opposite direction, because the chief catchment area would be the broad gentle slope toward the west and south. Here the tendency would be for the moisture, whether it was in the form of ice or water, to unite

MAP OF LUNAR APENNINES.

small streams together to form larger ones. Important rivers or glaciers would have their origin in this region, and would work their way downward, excavating broad valleys. The erosive effects, if not so rapid as on the east face, would, from the better presentment to us, be even more conspicuous, and there should be no difficulty in detecting the deposit of alluvium at the mouths of the great water courses. We do indeed find valleys and ravines on the western slopes, but these often are so blocked or show so many irregularities of level that they cannot be held to be water channels. If this was their original nature, then the more recent history of the moon must have entirely changed their appearance; we see nothing to remind us of the characteristic arrangement of a drainage area on the earth. More than that, we find in the neighborhood of Sulpicius Gallus a dark band parallel to the edge of the Mare Serenitatis, as if the Mare was actually deeper here than further out in the plain. Such a channel would have inevitably been filled up by the alluvium washed down by rivers draining the highland district.

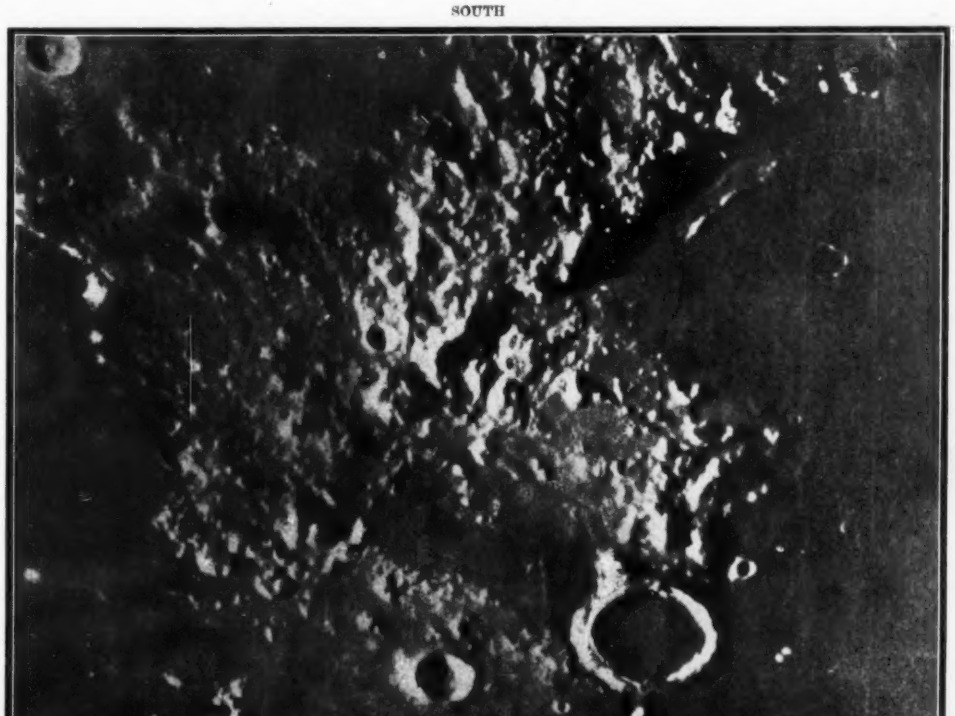
It is very instructive to watch the apparent changes time the brightest objects are the glittering peaks of the Apennine range, the rampart of Conon, and the white mantle surrounding Aratus. In early morning and late evening the gradual slopes of the highlands toward the west, and their steep declivities toward the east, are the regions which respectively shine out most conspicuously. But it is the latter which are by far the most brilliant, and there would seem not a little to justify Prof. W. H. Pickering's description of them as snow covered. "Many of the higher summits of the Apennines," he writes, "are brilliant with snow, although the sun is just setting upon them, while the slopes of the intermediate valleys and of the foothills are dark."

Prof. Pickering's interpretation of the brilliancy of the eastern* slopes of the Apennines involves several assumptions. He considers that the deposition of snow will vary on the moon according to the elevation of a district and according to its distance from the equator. But it should be borne in mind that elevation on the moon will not be nearly as effective in producing condensation as on the earth. The action of gravity at the lunar surface is but one-sixth of what it is with us. This would have a two-fold effect. While here we reach a region of half the surface pressure at a distance of $3\frac{1}{2}$ miles, on the moon we should have to ascend more than 21 miles to obtain the same proportional diminution, while the feebleness of gravity would make any upward motion of the atmosphere exceedingly slow. The cooling of an ascending current of air by expansion, here the most efficient cause of condensation, would there be practically inoperative, and the great tenuity of the lunar atmosphere would tend in the same direction. There would scarcely be any perceptible difference in the readiness with which condensation would take place between the plains and the mountain summits.

The comparison of the changes, too, does not support the inference that the bright regions are snow-covered. The western gentle slopes are by no means so bright under their best illumination as the steep eastern escarpments are under theirs. Yet it is on the former that we should expect the snow to lie, while as they are best lighted by the morning sun, that is to say, just as they emerge from the long lunar night when the snow should be thickest, we should expect them to be far more fully covered, and therefore more brilliant than the steep eastern slopes could be at sunset, after having undergone the continued action of the sun during the whole length of the lunar day. The changes in illumination are indeed just what we might expect from the varying incidence of the solar rays, provided that there was some difference in the reflective power of the different surfaces. And in this case there is no difficulty in pointing out a sufficient cause for the steep

SOUTH

WEST



EAST

NORTH

THE LUNAR APENNINES.

From a photograph taken March 4, 1895, at 6 h. 6 m., Paris mean time, with the Equatorial Coudé of the Paris Observatory. Moon's age, 8 d., 1 h., 7 m.

produced in any region of the moon by the progress of the lunar day. The change in the lighting produces an immense change in the general appearance of the region. The appearance of relief vanishes almost entirely at noonday; it increases directly in proportion to the obliqueness of the illumination, and is very marked at sunset. The two great craters, Archimedes and Eratosthenes, are practically lost at noon. At this

slopes being more brilliant than the gentle. Mr. Davison (Knowledge, December, 1896, p. 278) pointed out that objects on a slope, from the mere effect of the expansion during the heat of the day and contraction under the cold of night, would steadily creep down-

* I use the terms "east" and "west" throughout this paper, from our point of view. An inhabitant of the moon would, of course, regard the slopes facing the sunset as the western slopes.

ward. There would thus be a very slow but continuous transference of free solid particles from the summits of the mountains toward the plains, uncovering fresh surfaces in the higher regions, and this creeping effect would necessarily be much more rapid on such steep declivities as the eastern face of the Apennines than on the gradual slopes toward the west. If then, the very tenous atmosphere which we may readily believe to exist upon the moon be capable of effecting some slight tarnishing or darkening effect in the course of centuries, or if the deposition of meteoric dust, which must be much the same as upon our earth, slowly coats our satellite with a thin, dark veil, we shall find a sufficient explanation for the difference in albedo of the mountain peaks and of the great plains.—Knowledge and Scientific News.

A STRANGE SUBSTANCE FOUND IN AN EGYPTIAN TOMB.

Messrs. Lortet and Hugounenq have lately made an analysis of a substance which was found in the tomb of Prince Mahespa, Thebes XVIII. Dynasty; this tomb was explored not long ago. It lies in the valley of Biban-el-Molouk, near Thebes, and contained a quantity of interesting objects, which are now in the museum at Cairo. Among others were eight large jars stoppered with care, containing a pulverent yellowish mass. It was supposed that this substance was used in the mummifying process, but it had never been analyzed. Some of it was sent to Paris not long ago by Prof. Maspero, and it has been examined by the two experimenters. It is a grayish yellow and non-homogeneous substance, showing vegetable debris, sand, and clay. A quantity of it was treated first with alcohol, then with water. The alcohol dissolves out a yellowish-brown resinous matter, which has no doubt been changed with time, but it still possesses an odor. It is probably a mixture of resinous products in which the principal one is myrrh. It will be remembered that myrrh entered along with other ingredients, *Cyperus rotundus* and *Calamus aromaticus*, into the composition of kephi or kyphi, a sacred perfume which M. Lortet has reconstituted. Water dissolves out another portion, leaving a residue of quartz sand and clay mixed with sawdust and vegetable fragments. The primitive substance thus contains: Odoriferous resin, 19.53 per cent; organic debris, 3.68; sand and clay, 12.44; water, 9.52, and a mixture of soluble salts forming a natron, comprising sodium chloride, 14.88 per cent; sodium sulphate, 22.90; sodium sesquicarbonate, 17.05 per cent. The composition of the natron is more or less variable. A specimen from Gournah, near Thebes, gave sodium chloride, 62.00 per cent; sodium carbonate (dry), 18.44; sodium sulphate (dry), 11.40. Others are still different, such as one from Ouadi-Natroun. It is not only the origin and state of dessication which causes the difference, but the process of collecting it. The natron is found in flakes on the banks of the lakes or is scraped from the surface of aquatic plants. This latter method accounts for the vegetable debris which it contains.

As to the resinous substances found in the mixture, they cannot be identified with certainty, owing to the modifications which have been brought about by time and the surrounding media. In the alcoholic solution, myrrh seems to predominate, but it is accompanied by oliban and bdellium. There is no doubt that the substance found in the jars was used in preparing the mummies. The part which dissolves in water gives a brown color to the pieces of cloth which are dipped into it, and this is the same color as is seen on the bands in which the mummies are wrapped. When dry, the cloth presents an odor and appearance which are quite characteristic, owing to the deposit of alkaline soap which is produced by the resin mixed with the natron.

SCARLET PHOSPHORUS: A NEW CHEMICALLY-ACTIVE VARIETY OF RED PHOSPHORUS, AND ITS USE IN THE MANUFACTURE OF MATCHES.*

Part I.

By W. Muir.

The following observations sum up the results of experiments commenced by myself five years ago, to make a strike-anywhere match without white phosphorus.

After working on the substances that usually appeal to inventors, I tried the so-called red sulphides of phosphorus described by Berzelius, and found that they made good matches. I showed the matches prepared from those compounds to Mr. Boor, who took the matter up very heartily, and induced Dr. Marquart, of Messrs. Marquart & Schulz, Bettenhausen, Cassel, to make these sulphides (so-called) in large quantities. Matches also were made, but difficulties and doubts arose. We could not get the so-called red sulphides free from the ordinary yellow sulphides. The residue left, after extracting as much of the yellow sulphides as was possible, showed on analysis very little sulphur left, but it was unchanged in appearance and still made fair matches.

At this point we noticed an account of a peculiar form of phosphorus made by Prof. Schenck, of Marburg, with whom we got into communication through Dr. Marquart, and learned from him definitely, what we had already suspected, namely, that the so-called red sulphides of phosphorus are merely solid solutions of the ordinary yellow sulphides in some form of red phosphorus, and Dr. Schenck advised us that he had produced a new bright red preparation of phosphorus in his laboratory without the aid of any sulphur at all. I obtained quantities of this material, which we call Schenck's phosphorus, and made good matches. The result of our friendly intercourse was that we all joined our several discoveries and our practical knowledge together for the production of matches with this new scarlet preparation of phosphorus. (Specimens of the compound and of matches made from it were exhibited.)

We find that Schenck's phosphorus is a satisfactory basis for the production of strike-anywhere matches. It is not poisonous if swallowed, and it does not fume in working. It abolishes the special ills that have troubled match makers, and can be used with the ordinary glue mixture that is used with ordinary phosphorus. The matches made with it stand even better than those made with ordinary phosphorus. We have sent such matches to the most trying climates in the world, and have damped them and dried them twelve times without harming them.

Part II.

By R. Schenck, Ph.D., and P. Marquart, PhD.

You are all aware of the great importance of the two varieties of phosphorus as agents in many of our industries, and especially in the manufacture of explosives and matches. We now introduce a third form to you, which in some of its properties is intermediate between them.

The manner in which considerable quantities of our new form of phosphorus may be obtained has lately been demonstrated by one of us, who has also described its characteristics (Jour. Soc. Chem. Ind.), 1902, 368. See also 1903, 494). A very good sample of the new substance is obtained by heating a 10-per-cent solution of white phosphorus in phosphorus tribromide to boiling, and on this basis the firm of Marquart & Schulz, Chem. Fabrik, Bettenhausen, Cassel, have succeeded in working out a process which allows of the application of this new invention on a large scale.

The product is a fine powder of bright scarlet color, containing, however, still many impurities, as is shown by its weight, which may much exceed that of the white phosphorus used.

Its propensity to take up foreign matters from the solvents is very great. Michaelis and Pietsch tell us that red phosphorus formed by the effect of light on a solution of phosphorus in carbon bisulphide contains a large percentage of carbon and sulphur, and we, ourselves, have observed that foreign substances like iodide of phosphorus and sesquisulphide of phosphorus, which may be dissolved in phosphorus tribromide, together with the white phosphorus, are precipitated with it. This strong tendency to form solid solutions permits of the conclusion that the red phosphorus in the products is amorphous, as crystalline bodies rarely possess the capacity of dissolving foreign matters, except in cases of isomorphism.

On being raised to higher temperatures in an indifferent current of gas, Schenck's phosphorous becomes darker (while phosphoreted hydrogen is formed by the decomposition of the phosphorous acid), and finally turns black, recovering, however, its former redness on cooling down after some time. This reversionary alteration of color through change in the temperatures is a purely physical process, which has a good many analogies. Scarlet phosphorus that has been kept for a long time at high temperature retains, when cooled down, a deep red color.

The great chemical activity of this form of phosphorus is shown by the violence with which it becomes oxidized by diluted nitric acid; it is shown also when treated with hot caustic soda solution which causes a generation of phosphoreted hydrogen, and a solution of the scarlet powder into the subphosphorous acid. Ordinary amorphous phosphorus is hardly attacked by hot caustic soda solution; it may be indeed freed from small quantities of white phosphorus by being boiled down with this liquid. A weak solution of indigo in sulphuric acid is decolorized if boiled with scarlet phosphorus.

A particular characteristic of scarlet phosphorus is its action toward ammonia and bases of medium strength, such as dilute piperidine and diethylamine. They turn its bright red color black, phosphoreted hydrogen being formed to a small extent. Acids will reproduce the scarlet product from the black. The black products seem to be salts, and successful experiments have been made to fix the nature of their acids. The salts are those of a solid polyphosphoreted hydrogen, which certainly is not usually regarded as an acid.

Difficulties which have not been removed yet by industrial science have prevented the introduction of the amorphous red phosphorus, which at first seemed predestined for the preparation of non-poisonous strike-anywhere matches, and the hopes entertained in that direction have not been realized. The mixtures of amorphous phosphorus with oxidizing substances, such as chlorates, and with other bodies, such as filling and cementing agents, which are used at present to form match heads, possess the objectionable quality of being highly explosive, so that great losses are incurred through their employment, and the workman is exposed to considerable danger.

If, therefore, in the tips of matches, the scarlet phosphorous be substituted for the white phosphorus, an article will be obtained, which, while non-explosive, after drying will easily ignite on any rough surface. A technical problem of long standing will thus have been definitely solved.

DISCUSSION.

Sir Wm. Ramsay said he had recently visited Marburg, and had been shown a cat which had swallowed about 50 grammes of this phosphorus without suffering any harm. This substance had a slight smell resembling that of ordinary phosphorus, which appeared to indicate that it formed the oxide of phosphorus, P_4O_6, discovered by Dr. Thorpe, some years ago, which was the cause of the "phosphrus" smell. It was a curious fact that yellow phosphorus was an unstable substance, or, more correctly, a meta-stable substance; it was in the same condition as water cooled below zero, which yet did not freeze. Yellow phosphorus changed so slowly that it could not be seen to change under ordinary circumstances; even when kept below water, its transformation into the red variety was very slow, but if it were dissolved the rate of transformation increased very greatly, and on that depended the merit of this discovery, dissolving the phosphorus in the bromide. He saw the experiments which had been described, and it occurred to him whether this new form was not conceivably a solid solution of hydride of phosphorus, P_4H_2, in red phosphorus, or a mixture of the two. This was suggested by the action on ammonia and certain bases described. No doubt these formed compounds which strongly resembled polysulphides. A precipitate was obtained which turned red, which Dr. Schenck said was hydride of phosphorus, mixed with ordinary phosphorus. In the same way if an acid were added to polysulphide of sodium a precipitate of sulphur was formed, with the difference that in this particular instance a solid sulphureted hydrogen was not obtained, but merely sulphureted hydrogen gas; whereas, in the case of phosphorus, the solid hydride P_4H_2, remained mixed with the precipitate of phosphorus. He was not clear whether Dr. Schenck thought the substance was really this mixture of hydride and red phosphorus, or the latter only. So much for theory; on the practical side, it occurred to him that there must be a considerable loss, if the phosphorus tribromide adhered so strongly as only to be decomposed by boiling water. It was possible that the hydrobromic acid might be recovered, and also the phosphorus, but he should have thought there was a considerable amount of loss possible from the fact of having to decompose a large amount of phosphorus tribromide which had to be reconverted from its elements before they could be again utilized. That loss might not be sufficient to negative the gain, but it must be reckoned with. The differences might be got over, but he should have thought, owing to the waste, that it was an uneconomical operation. He should be glad if Mr. Muir could give any information on this point.

Mr. L. G. Boor said that, with regard to the practical side, what they had done so far was to provide a match which could be made with the ordinary 20 per cent gelatin composition, and would stand any climate. They tried it with the idea of producing a match which would strike anywhere. They simply substituted this red phosphorus for the common yellow, so that the match maker could use the same composition which he had used for years without altering his plant or his process. With regard to the cost, it would always be higher than that of yellow phosphorus, the same as amorphous phosphorus, but with the question of prohibition looming in the future, and matches at 1s. a gross, he did not think an extra ¼d. a gross would prevent the use of this kind of phosphorus.

Mr. Bale asked the price of this particular compound.

Mr. Boor said, as produced at present in small quantities, it worked out about 2s. 3d. per pound, but he believed that, when made in large quantities, the price of this red phosphorus would be brought down to about the same as that of amorphous, about 1s. 9d.

Mr. Clayton asked the ignition point of the new phosphorus, and if the substance described in the first paper was the same as that prepared by Dr. Schenck.

Dr. Divers remarked upon the interesting fact that a body which has been known to every chemist from the time of Thénard and even before it, should only quite recently have been shown by Dr. Schenck to be very stable and apparently very useful. It seemed important that its non-poisonous character should be further tested upon herbivorous as well as upon carnivorous animals; parts of the human alimentary tract secreted alkaline fluids which might act upon this body and generate poisonous products.

Prof. Mills asked if any figure could be given as to the yield of this phosphorus from a definite quantity of common phosphorus, and also, as phosphorus tribromide was rather expensive, whether the trichloride could not equally well be used under pressure.

The chairman said one point appeared to him to require some further experiments, namely, the action of the phosphorus itself on the cementing material, which Mr. Boor said was gelatin or glue. He asked Mr. Muir whether any experiments over any length of time had been made on the action of phosphorus on this organic material. Of course, it was a very great advantage, not only from the point of view of the swallowing of matches, but also of their contact with the skin that the phosphorus was inert. If an absolutely non-poisonous phosphorus were introduced into the match trade it would eliminate much serious suffering. The poorer classes of operatives engaged in the match trade suffered very seriously, in spite of all that had been done by legislation for their protection; in fact, so great was this evil that the use of ordinary phosphorus for this purpose had been prohibited in many European countries.

Mr. Muir, in reply, said he found the ignition point

* Read before the Society of Chemical Industry.

was about 170 deg. C. A good deal would depend on the rapidity in the rise of temperature. The substance mentioned in both papers was the same. The matches shown were made with it; they were produced from material sent over by Prof. Schenck. He had tried phosphorus trichloride, and he thought under pressure it might give some results. They had had matches in stock which were two years old, and they were as good now as when they were made.—Jour. Soc. Chem. Ind.

TRADE NOTES AND RECIPES.

Vegetable Substitutes for Soap.—The adaptability of plants for washing purposes has long been known. They possess the advantage over soap in that their effective substance, saponine, is a neutral or slightly acid body, while soaps always form free alkali with water, which often attacks the colors of the material. So far as is at present known the cleansing effect of saponine results from its ability to produce in water a great quantity of insoluble particles very finely divided in the form of an emulsion.

Its peculiar property of foaming when shaken is intimately connected with this.

Of *musa paradisica* alone is it said that the sap contains a solution of sodium oleate, and that it may be used in the place of soap, without containing any saponine.

Mr. L. Rosenthaler presents a list of vegetable substitutes for soap which shows a preponderance of the leguminous plants, at the head of the list the *mimosadæ*—albizzia and acacia.

In the second place come the *caryophyllaceæ* with our indigenous *saponaria officinalis*, after them come the *Rosaceæ*, containing exclusively *quillaja* varieties. The roots and root stocks and bulbs are used for the most part, then the bark, and some times the leaves and fruit; the *phaseolus mungo* indigenous to the East Indies is the only species of the *papellionatæ* given of which the blossoms may be used.

Practical Hints in the Production of Artificial Kindling Sticks.—Pitch, gum, rosin, or any similar easily-burning and melting resins are melted in an iron pot; in this molten mass a given quantity of calcined lime is sifted and vigorously stirred, and when the compound flows thin it is set aside to settle.

The addition of lime is ordinarily about one-tenth of the amount of rosin or pitch used.

Prepare, furthermore, in large earthen pots, aqueous solutions of all sorts of aniline dyes with which to stain sawdust. The very finest dust must be removed and the coarser sawdust poured into the dyes until it takes them up completely. Next dry and mix certain amounts of all the colors with a sufficient quantity of unstained sawdust to form a brilliant and pleasing combination of color. Finally, dip thin bits of wood or thick shavings in the still warm fluid rosin and sprinkle them lightly with the variegated sawdust and stand apart to dry.

Any rosin which is easily ignited is suitable for saturating the splints or shavings; the main desideratum is that it be cheap.

The calcined lime is added only to cause the rosin to harden more quickly, and if hard rosins be employed the lime may be left out of the compound.

Of course economy will teach the operator that the rosin is to be kept as thin as possible, and for the dyes the cheapest aniline colors will do, since they serve no other purpose than to make the kindling sticks acceptable to the eye.—Erfindungen und Erfahrungen.

On the Warping of Circular Saws.—This damaging defect in saws of this description arises from the unequal tension existing in the metal itself, and may come from a variety of causes.

To begin with, according to the Zentralblatt für die oesterreich'sche-ungarische Papier-industrie, this may occur during the manufacture of the saw, either in the annealing or hardening, or may be discovered after long use; as a general thing it may be accepted that a fault consequent upon one of the former causes will be discovered early enough to prevent the article from reaching the hand of the consumer.

It often happens also that too great speeding of circular saws will cause warping, for during excessive revolutions the centrifugal force, particularly in the larger saws, tends to stretch the plate unevenly.

It is important, then, when buying circular saws to inquire of the maker or dealer at what rate the saw may be safely run; or, in other words, for how many revolutions per minute is the saw calculated.

It is natural enough to conceive that, with so great a variation in the speeds—from 800 to 2,500 turns a minute—all saws are not fitted for the same velocity. Warping of a saw disk that has become hot may be avoided if it be properly treated; it should, for instance, not be cooled too rapidly. In all mills where saws of this description are used it should be an established rule not to cool an overheated saw with water, as is indeed the practice in nearly all mills, nor should its power be instantly shut off and it be allowed to stand either.

At least five minutes of free running should be allowed such a saw, and then run it down gently, so that by degrees its particles may assume their normal positions.

At most a current of air only should be used in the cooling; from water the shock to the internal structure is too great.

ELECTRICAL NOTES.

A scheme, undoubtedly new to many, for the delicate statical balancing of armatures and other revolving parts, is illustrated in the July issue of the Electric Club Journal. The shaft supporting the armature is not laid directly upon the balancing ways, but is encircled with a hardened steel ring at each end, which has been accurately ground and polished. Though these rings do not fit the shaft, they make the balancing test perceptibly more sensitive. When a soft steel shaft carrying a considerable weight is laid upon the balancing ways, there is some local deformation at the points of contact that tends to make it lie in whatever position it happens to be. With the hardened rings around the shaft this local deformation is largely neutralized; the rings being hard do not change shape so much as a steel shaft in contact with the ways, and the shaft itself bears on the inside of the rings where it is supported by a considerably greater area of contact, even when the rings are two or three times larger than its diameter.

An international congress will be held in Paris in June, 1905, with the object of investigating apparatus to insure the greater safety of workmen employed on high-tension conductors. The form the apparatus should take is a device indicating safely and clearly whether any conductor is alive or not. It must be equally applicable to direct and alternating current of all voltages, must be thoroughly reliable and incapable of doing damage to itself, the operator, or the distribution system under any circumstances. The congress is being organized by the "Association des Industriels de France contre les Accidents du Travail," and a prize of 6,000 francs will be awarded to the exhibitor whose apparatus most nearly fulfills the conditions. Intending exhibitors should send a full description, with necessary drawings, of their apparatus, to the president of the association, 3, Rue de Lutece, Paris, before December 31 next. All systems presented will remain the property of the inventors, who should take the necessary measures to protect their rights. Further information may be obtained from the director of the association at the above address.

In the Elect. World and Engineer S. E. Doane gives a résumé of the different methods used for exhausting incandescent lamps, and considers seriatim their respective advantages and disadvantages. He deals at some length with mercury pumps of the Sprengel type, and the Geissler form of pumps, and points out that the chemical process of exhausting is the more satisfactory one than the mercury-pump system. The chemical process, which is fully described by the author, consists roughly of mechanically exhausting a heated lamp to a pressure represented by a column of mercury of 0.125 millimeter high. The lamp is sealed off from the pump, and phosphorus is vaporized, and passes into the lamp bulb while the filament is very hot, and while an electric current is passing through the gaseous contents of the bulb. The vapors of this metal enter into an electro-chemical combination with the gases, forming solid precipitates if the conditions are proper. A series of useful hints are given, which have to be observed if good results are to be expected. Much of the improvements in lamp quality can be traced to better methods of exhausting. The present existing system has its faults, and they are as follows: We must still depend upon the skill and judgment of the individual operator. We still depend upon a system of pipes and valves which will occasionally develop leaks. Pumps occasionally get out of order, and the chemical reactions which produce the vacuum are sensitive, and atmospheric and chemical conditions occasionally give us new problems.

C. P. Steinmetz has discovered that magnetite, the black oxide of iron, is suitable for use as an electrode in an arc lamp. From investigations which have been made with different materials, it appears that the arc flame issues from the negative terminal, and striking the positive produces heat. If the positive electrode cannot convey the heat away fast enough, it becomes hot, as in the case of the carbon arc. For this reason the flame-coloring substances are introduced into the positive electrode in the Bremer and other lamps. In the magnetite lamp the positive electrode is a copper segment, which is of such size that it does not get too hot, and therefore does not wear away, forming a permanent part of the lamp. On the other hand, it gets sufficiently hot to avoid the deposition of material on it which may be shot out from the negative electrode, consisting in this case of fused drops of magnetite. Among the conducting oxides magnetite is best suited for the arc lamp, since it conducts well, is stable at all temperatures, very plentiful in nature, and gives a white arc of high efficiency, about twice as great as that of the carbon arc. It burns at the rate of ¼ inch per hour, which is low as compared with the rate of burning of the flame arc, which is from 1 to 2 inches per hour. Other substances, such as titanium compounds, are, however, added to the magnetite to reduce the rate of burning. With small sacrifice of efficiency 8-inch electrodes can be produced which will burn for 500 to 600 hours. A simple and satisfactory form of electrode is that in which the material is compressed in the form of an impalpable powder within a thin iron tube, which is then sealed up in the arc. In this lamp none of the light comes from the positive terminal, but from the column of vapor, which is from ¾ inch to 1¼ inch long. The feeding mechanism is so arranged as to maintain the electrodes in fixed positions till the length of the arc has increased to such an extent as to cause the feeding arrangements to reset the arc to its original length.

ENGINEERING NOTES.

The United States consul at Birmingham, England, reports that some of the tube-making mills in his district are being "Americanized," skilled tube makers having been imported from Pittsburg and vicinity to reform the British system of tube making. The consul remarks that the men are brought over under five, three and one year contracts at wages several times greater than the ordinary wages paid in the Birmingham district, and at an advance over the wages paid for such labor in the Pittsburg district, but that there are some disappointments in store for them. In the first place the common impression abroad that living is cheap is erroneous—that is, on the scale to which the average American workman has been accustomed Food and clothing are dearer than in the United States, and it is difficult to find houses with modern conveniences for rent that are within the reach of the imported workmen and near the works. Moreover, the imported men have to pay a good big income tax—something that they had not calculated on when accepting the job.

The problems of deep hoisting may perhaps be arbitrarily assigned to depths below 2,000 feet vertically. The iron mines of the Lake Superior district I believe have no shafts reaching this limit, but the copper country offers a variety of solutions of the problem. The depths here exceed those in any other locality, Tamarack No. 3 being 4,990 feet and No. 5, 4,935 feet deep vertically. The single vertical shaft of the Calumet & Hecla reaches 4,900 feet, while there are many shafts on the incline exceeding 5,000 feet. I believe that here there are more really great hoisting engines in a small area than can be found in any other district. That these engines are not of a single type, even when the service to be performed is identical, shows that the several designers have by no means arrived at an entirely satisfactory compromise of the conflicting requirements of the ideal deep hoist. To propose a solution solely from the viewpoint of the mechanical engineer is but to include half the elements of the problem, for the success of the hoist depends on a sympathetic treatment of the miner's needs, not only in times of smooth and normal running of mining affairs, but in times of disaster and mishap. Where the quantity of material to be handled through a single shaft is as great as it is in this district and where the cost of a shaft before the period of production may reach well toward the million mark, the interest cost due to a shut-down on account of the failure or complication of the hoisting mechanism must also be carefully considered in connection with the mechanical solution of the problem.—O. P. Hood, in Mines and Minerals.

Auxiliary relief valves were used some fifty years ago on steamboats on the Mississippi River, and old hoisting engineers report having seen them in use on the Comstock Lode at an early date. William Bates, hoisting engineer at Mine No. 5 (which shaft is now used as an escape shaft), Consolidated Coal Company, Staunton, Macoupin County, Ill., probably first applied the relief valve to Litchfield hoisting engines; and he doubtless was the first to use such valves in the Middle West. These particular engines are first-motion, 16-inch x 30-inch x 8 feet drum, and were among the first, if not the first, double-hoisting engines made by the Litchfield Car and Machine Company. They began the work of hoisting coal in October, 1881, and were run without a relief valve until July, 1882. During the eight months these engines were in operation, several accidents occurred, while new or strange engineers were lowering men in the morning, and the miners became timid. The engines would often come to a dead stop or rebound 10 or 20 feet up the shaft. Several men were injured by rebounds of cage while stepping on or off the cage at the shaft bottom. Mr. Bates conceived the relief valve (it is doubtful whether he had ever seen one, although they were in use in other parts of the country) and advocated its adoption in the face of some opposition. The relief valve was finally installed and adjusted to the requirements of the load, and the 250 miners were lowered in safety from this time on. Mr. Bates, who is still alive, and has kindly furnished this historical data, says he never heard of an accident in lowering men when the engineer used the relief valve. This is a rather strong statement to make, but I can say that in my experience the relief valve is a very valuable accessory to a hoisting engine. Our engines in the Middle West can reverse in less time than any other hoisting engines of which I know, and are easier handled than large engines not equipped with relief valves. The relief valve consists of an arrangement of pipes and a quick opening valve, located within easy distance of the hoisting engineer. These pipes are connected with the throttle on the dead side and discharge the steam or air into exhaust pipes near the cylinders. The object of the latter connection is to return the hot air, or steam, to the engines to be used over and over again to keep the cylinders hot, as an outside discharge would cause excessive cooling, especially in winter. The object of the relief valve is to regulate and maintain a uniform velocity when lowering heavy loads. Both engines are converted into air compressors when reversed against their run. The engineer simply discharges or retains the air to meet the requirements of load and speed. The relief valve is useful in discharging water due to condensation of steam in the steam pipes, in relieving steam pressure of the boilers when hoisting stops, preventing dangerous accumulations of steam pressure, keeping water hot in the heater, and, lastly, in avoiding danger due to runaway of engines, due to leaky throttle valves.—J. J. Rutledge, in Mines and Minerals.

SCIENCE NOTES.

The Manchester ship canal is reported to have suffered a breach in one of its walls near Runcorn, where especial difficulty was encountered during construction. When the tide is out 70,000 to 100,000 gallons of water per hour are estimated to flow into the Mersey River, but the return of the tides prevents any appreciable difference in the canal water level, apparently.

A little museum of the most modest pretensions has been recently constituted in Famagusta, Cyprus, for the purpose of housing the valuable fragments of sculpture which for more than twenty-five years have littered the Zaptieh barrackyard, in the middle of the ruined city. It is to be hoped this is the beginning of good things, as far as Cypriote antiquities are concerned. The collection of fragments now rescued from a miserable condition has been to a great extent illustrated in the great work on "L'Art Gothique et de la Renaissance en Chypre," published by M. Enlart, at the cost of the French government, in 1899. Would that we could record the institution of similar "provincial museums" in other parts of the island, for preserving the interesting remains of mediæval art still surviving in private possession, or abandoned to the tender mercies of government officials.

The Dominican, published at Roseau, Dominica, has printed a paper by Mr. F. Stearns-Fadelle on the boiling lake of that island. It was unknown until 1875, when a gentleman who had lost his way in the forest approached the lake near enough to be aware that he was in the neighborhood of a center of subterranean ebullitions. His report led a party to go in search of it. The search was rewarded by the discovery of the lake, which is elliptical in form, about 200 by 100 feet in measurement, and stands 2,425 feet above sea level in the midst of a volcanic area some five square miles in extent. When fullest it drains into the Pointe Mulatre stream. At times it is quiescent, and then it may be ebullient for days at a time. It has not yet been ascertained whether ebullition occurs at definite periods. Vertical cliffs of ferruginous soil and rock rise from the water, and in sounding ten feet from the edge of the lake no bottom was found at a depth of 195 feet. Sulphureted hydrogen is exhaled, at intervals, and the gas proved fatal to a visitor and guide in 1901, while other visitors have suffered from its effect. When the water is quiescent it is still a lake, showing that this is not merely the outer part of a subterranean funnel. The volcanic region in which it is situated is called Grande Soufriere.

As observed by geologists at various times, not only are gaseous, liquid, and solid hydrocarbons among the more important products of solfataric volcanic emanations, but also acid vapors, sulphureted hydrogen, gypsum, and calcareous and siliceous waters. That such volcanic phenomena represent the normal and orderly process of petroleum production appears to be a clearly established geological fact, for reasons which are stated by Mr. Eugene Coste in a paper recently read before the Franklin Institute. It is interesting to note that, as pointed out by the author, the oil, sulphur, salt, natural gas and hydrogen-sulphide products of the Texas Coastal Plain are not indigenous to the strata in which they are found, but are resultant products which have ascended, under volcanic pressure, at points along lines of structural weakness, and have been disseminated through thousands of feet of the shales, sands, and littoral sediments of the same region. After an exhaustive discussion of the subject, Mr. Coste arrives at the important conclusion that as oil and gas have only been supplied along lines of structural weakness, or along fractured zones of the crust of the earth, new oil and gas fields are to be looked for only along such belts or zones. Existing oil and gas fields serve to indicate the position of numerous oil belts, and the author suggests that, so far as practical results are concerned, the important point is to accurately trace the fissured areas on reliable maps, and to drill in the localities thus indicated.

It is remarkable that in the recent investigation by the British government into the causes of the alarming increase of miner's phthisis, the very causes which might have seemed most likely to have given rise to it were found to be absolutely innocuous, such as damp mines; powder smoke; coming up from a damp, cold mine, or the contrary, into the open air; the cramped position of the body in working, and the like. The root of the matter was finally traced down to the following: (1) Metalliferous miners are exposed to the inhalation of dust from hard stone. (2) The inhalation of such dust is known from experience in other employments to cause phthisis and other lung diseases. (3) No other suggested cause associated with work in metalliferous mines is capable of explaining the excessive liability of metalliferous miners to lung disease. (4) The miners most exposed to dust are most liable to lung disease. It would seem as if the injurious influence of dust on the lungs was purely a mechanical one, no poisoning from chemical ingredients being discovered. To prevent miner's phthisis, four different methods suggest themselves: (1) To use respirators to filter off the dust. (2) To prevent, as far as possible, the giving off of dust into the air. (3) To carry it away when given off. (4) To arrange the work in such a way that dust, when given off into the air, is avoided by the men. It is also recommended that by the use of sprays and other water devices dry mining should, as much as possible, be converted into wet mining. Blasting should be so arranged that men remain in pure air and do not return until the dust has cleared.—Mines and Minerals.

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